THE

VOYAGE OF H.M.S. CHALLENGER.

ZOOLOGY—VOL. XVII. v 20 - pt. 3

REPORT

ON THE

SCIENTIFIC RESULTS

OF THE

VOYAGE OF H.M.S. CHALLENGER

DURING THE YEARS 1873-76

UNDER THE COMMAND OF

CAPTAIN GEORGE S. NARES, R.N., F.R.S.

AND THE LATE

CAPTAIN FRANK TOURLE THOMSON, R.N.

PREPARED UNDER THE SUPERINTENDENCE OF

THE LATE

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AND NOW OF

JOHN MURRAY

ONE OF THE NATURALISTS OF THE EXPEDITION

ZOOLOGY—VOL. XX.

PART LXII.—REPORT ON CEPHALODISCUS DODECALOPHUS

BY WILLIAM C. M'INTOSH, M.D., LL.D., F.R.S., &c.

Published by Order of Her Majesty's Government

PRINTED FOR HER MAJESTY'S STATIONERY OFFICE

AND SOLD BY

LONDON:—EYRE & SPOTTISWOODE, EAST HARDING STREET, FETTER LANE
EDINBURGH:—ADAM & CHARLES BLACK
DUBLIN:—HODGES, FIGGIS, & CO.

1887

Price Four Shillings.

PRINTED BY NEILL AND COMPANY, EDINBURGH,
FOR HER MAJESTY'S STATIONERY OFFICE.

EDITORIAL NOTE.

This Report consists of a description by Professor William C. M'Intosh, F.R.S., of Cephalodiscus dodecalophus, one of the most curious and interesting organisms dredged by the Expedition, with an Appendix on its affinities by Sidney F. Harmer, B.A., B.Sc., Fellow of King's College, Cambridge. It contains forty-eight pages, and is accompanied by seven plates and woodcuts.

The Manuscript was received in instalments between 25th April 1887 and 19th May 1887.

John Murray.

Challenger Office, 32 Queen Street,
Edinburgh, 22*nd July* 1887.

THE

VOYAGE OF H.M.S. CHALLENGER.

ZOOLOGY.

REPORT on CEPHALODISCUS DODECALOPHUS, M'Intosh, a new type of the POLYZOA, procured on the Voyage of H.M.S. Challenger during the Years 1873–76. By WILLIAM C. M'INTOSH, M.D., LL.D., F.R.S., &c., Professor of Natural History in the University of St. Andrews.

Class POLYZOA, J. V. Thompson.

Section ASPIDOPHORA, G. J. Allman.

Genus *Cephalodiscus*, M'Intosh.

Cephalodiscus dodecalophus, M'Intosh.

Cephalodiscus dodecalophus, M'Intosh, Ann. and Mag. Nat. Hist., ser. 5, vol. x., 1882, p. 337, *et seq.*

Among the collections made by the Challenger Expedition in the Strait of Magellan, there was a structure which, from its external appearance, was in the first instance placed among the Compound Ascidians. When it was found not to belong to this group Mr. John Murray forwarded the specimen to various authorities for examination, and my attention was drawn to the anomalous organism in the hope that it might be found to have affinities with the Annelida. An examination of this remarkable type proved that amongst its other affinities it was an ally of *Rhabdopleura*, a new type of the Polyzoa which had been ably described and figured by Professor Allman in 1869[1] from

[1] *Quart. Journ. Micr. Sci.*, vol. ix., N.S., 1869, pp. 57–63, pl. viii.

specimens procured at a depth of 90 fathoms in the Zetlandic Seas by Drs. Gwyn Jeffreys and Merle Norman, which had received further elucidation at the skilled hands of Professor G. O. Sars,[1] as an inhabitant of the still waters in the deeps off the Lofoten Islands. Though it thus fell within the department of Professor Allman, or that of the late lamented Professor Busk (each of whom had arrived at a similar conclusion in regard to its systematic position), yet both most disinterestedly desired that its description should remain in my hands. A preliminary account accordingly appeared in the Annals and Magazine of Natural History for November 1882,[2] having been previously communicated to the Southampton meeting of the British Association.

The specimens of this remarkable form were trawled at Station 311 (in the Strait of Magellan), January 11, 1876; lat. 52° 45′ 30″ S., long. 73° 46′ 0″ W.; at a depth of 245 fathoms; bottom, blue mud; temperature at the bottom 46°·0, surface 50°·0; specific gravity at the bottom 1·02454, surface 1·01904. The bag of the trawl in this region was filled, Mr. Murray tells me, with a vast mass of *Hemiasters*, numerous examples of a *Venus*, and multitudes of Compound Ascidians, four species of which have been described by Professor Herdman, who also noticed the distinction between *Cephalodiscus* and the Ascidians. Further, in connection with the habitat of the new form, it is interesting that several peculiar molluscoid rarities had previously been found in the Strait of Magellan by Professor R. O. Cunningham, naturalist on board H.M.S. "Nassau," such as his *Goodsiria coccinea*, a long, lobed, rooted fibro-gelatinous mass of a vivid scarlet colour, with the minute flask-shaped animals in circumferential cells, and the equally curious *Pyura molinæ*, of Blainville. Thus if the Strait be not the head quarters of peculiar Molluscoida, it is certainly one of the centres round which many are grouped, including the present new type—perhaps the most remarkable of them all.

Amongst the branches of the cœnœcium of *Cephalodiscus* were a few minute Arachnida, sessile-eyed Crustaceans, fragments of Annelids and sponges, besides many Foraminifera of the Rotulate type, which were chiefly studded on the spines (or filaments) and other parts.

[1] On some Remarkable Forms of Animal Life, &c., vol. i., 1872, pp. 1–18, Tab. i., ii.
[2] Ser. 5, vol. x. p. 337.

DESCRIPTION.

The description of this peculiar type may be taken under the following heads :—

I. The House or Cœnœcium ;
II. The Polypides, including—
  a. Buccal disk.
  b. Branchial plumes.
  c. Digestive system.
    Mouth.
    Pharynx.
    Œsophagus.
    Stomach.
    Pyloric chamber.
    Intestine.
    Food.
  d. Body-wall and body-cavities.
  e. Muscular system and pedicle.
  f. Nervous system.
  g. Reproductive organs.
  h. Budding.
III. General Remarks and Homologies.

I. Cœnœcium.

At first sight the flexible cœnœcium might be mistaken for a sea-weed, since it is composed of a much branched fucoid tissue, tinged of a pale brownish hue, and semi-translucent. Moreover the whole surface of the thickish stems is hispid with long tapering spinous processes or fimbriæ of the same tough secretion, and perforated here and there by somewhat large apertures with smoothly rounded edges. A more minute inspection reveals various opaque bodies in groups in the interior of the branches; and the appearance of these suggested the relationship of the structure to the Polyzoa or Ascidians. When first seen in the Strait of Magellan it was supposed, Mr. Murray observes, to be a Compound Ascidian. After being subjected to more careful examination on the completion of the voyage, the late lamented Professor Busk, however, pointed out its distinction from the ordinary Polyzoa; while Professor Herdman, as already mentioned, was satisfied it did not fall under the Ascidians.

The house or cœnœcium of *Cephalodiscus dodecalophus*[1] (Pl. I. fig. 1) consists of

[1] κεφαλή, head; δίσκος, disk; δώδεκα, twelve; λόφος, plume.

thickish, irregularly rounded or flattened stems of the consistency of soft sea-weed, and having a slight lustre like the semitransparent tubes of many Annelids. The stems have a diameter varying from four or five millimetres to double or treble that breadth in the flattened expansions; but the general size of many of the branches is nearly uniform. They cover a considerable area with their network, the extreme length in one example being about 9 inches, and the breadth 5 or 6 inches. The main trunks appear to have sprung from submarine objects, such as stones or sponges, but instead of standing erect as in a soft Gorgonian, to which the inosculations of the branches give it some resemblance, they seem to have been more or less horizontal, since pillars of the

FIG. 1.—Fragment of Polyzoarium of *Cephalodiscus dodecalophus*, M'Intosh.

cœnœcium occasionally pass, like aërial roots, from the underside to the plane of attachment. Various foreign bodies, such as tubes of Serpulæ and portions of sponge, are, moreover, occasionally enveloped by the cœnœcium, the originally soft secretion having insinuated itself into all the irregularities of their surfaces, and extended around and beyond them. The surface of the branches is everywhere studded with elevations and ridges, which terminate in long spines of the same tissue—simple, bifid, trifid or multifid—and here and there bending downward to join the main stem, so as to form loops and arches, or inosculating with adjacent spines or fimbriæ (woodcut, fig. 1). Some of the

spinous processes are very large, and project far beyond the others, while occasionally they occur in groups. They generally taper a little towards the tip, which is often attenuate, and of a deeper brownish hue than the rest of the cœnœcium (Pl. VII. fig. 1). The free tips of the branches frequently show a somewhat palmate arrangement, with longer spines variously divided. The irregularity in regard to the distribution of the spines recalls the processes on the peculiar sponge *Chondrocladia,* though this feature is much more marked than in the latter. All the spines are hollow, and in connection with the canals and cavities of the cœnœcium.

The surface of the cœnœcium, moreover, is dotted, especially at the bases of the spines, with large rounded apertures, which lead into the interior of the stem, the latter being honeycombed from end to end by an irregular system of wide canals and somewhat rounded cavities, intersected by bridles and arches, which thus provide for the constant ingress and egress of sea-water throughout the entire system. The inner wall of these canals and chambers is as smooth and glistening as the outer surface of the cœnœcium, the secretion being perfectly homogeneous. It cuts with great readiness, and as cleanly as a soft *Fucus;* while it is much less tough than the glistening tubes of the Annelids. Microscopically it is composed of numerous layers of a translucent and very fine membranous secretion, so that in the preparations there are endless lines and folds, while the sheen or lustre is doubtless due to the same arrangement.[1] The whole disposition of the tissue clearly indicates that it is the work of the polypides, just as much as the tube of an Annelid or *Phoronis,* the more regular and less bulky tube of *Rhabdopleura,* and in some respects the shell of a Mollusk. Like the Annelidan tubes it most approaches, it is little affected at first either by nitric acid or caustic potash, though the former after a time somewhat softens and bleaches it.

This secretion of *Cephalodiscus* is paralleled by the curious investment or "house" of *Appendicularia,* which by some has been held to be the homologue of the Ascidian test, and which fills the tow-net with a semi-solid mass when the animals are abundant. It differs considerably from the branched system of annulated tubes formed by *Rhabdopleura,* each of these corresponding to a single polypide, while the rings of which it is composed are successively produced at the termination of the tube by the secreting powers of the great buccal shield or præ-oral disk. Professor Lankester, moreover, has very clearly explained[2] that the differences of the rings in the attached or recumbent part of the tube and those of the erect portion—differences first pointed out and figured by Professor Allman[3]—are due to the changes in the buccal disk which secretes them, this disk being characteristically bifid in the young specimens which form the recumbent portion of the tube. This symmetry and regularity are absent in the house of *Cephalo-*

[1] All these features are well seen in a series of skilful sections mounted by the dextrous hands of the late Professor Busk.

[2] *Quart. Journ. Micr. Sci.*, vol. xxiv., N. S., p. 625.

[3] *Journ. Roy. Micr. Soc.*, vol. ix. pp. 61–62, pl. viii. figs. 4, 6, &c., 1869.

discus, apparently because the polypides are not restricted and regulated in their labours by the contractile stalk, but are free to wander throughout the cœnœcium, and to add layer upon layer to strengthen their protective investment. The buccal shield is in all probability the chief secreting organ, the great sheets of membrane, consisting of the secretion hardened in sea-water, being formed by its agency, but the shape of the spinous processes or fimbriæ suggest some other assistance, such as might be obtained from the enlarged and glandular tips of the plumose arms.

While there can be little question that the protective house of *Cephalodiscus* differs materially from the thickened cuticle of the posterior region of the polypides in the ordinary Polyzoa, and which collectively is termed zoœcium, yet it seems unnecessary to complicate the subject by the introduction of new nomenclature.[1] The term cœnœcium as instituted by Professor Allman, and which was used in the preliminary description, points to an obvious character, and gives that amount of significance which it is always well to preserve if possible in scientific terms. The term tubarium, proposed by my friend Professor Lankester, is very appropriate in the case of *Rhabdopleura*, but does not apply to the condition in *Cephalodiscus*, in which the common abode of the polypides is more aptly indicated by the already existent term cœnœcium.

It is not a matter for surprise that creatures so minute should secrete so conspicuous a home for themselves, or that it should assume the algoid or zoophytic outline, especially when the productions of sponges and other forms are remembered, or when we reflect that even a transparent structureless fluid inside a smooth capsule (as in the Nemertean stylet-pouch) can produce, in countless examples of each species, precisely the same form of solid crystalline stylet. The enlistment of numbers in the present case supplies any deficiency likely to arise from minute size. The secretions, indeed, both of this form and *Rhabdopleura*, are most interesting, and indicate a degree of skill and persistence of pattern quite as marked as in much more elevated types. The condition in *Cephalodiscus* is perhaps the more striking of the two, on account of the perfect freedom of the polypides, the spinous processes or fimbriæ of the surface, and the numerous anastomoses of the cœnœcium. The peculiar shape of the latter, moreover, has probably been found to be that best adapted for the preservation of the animals, by its resemblance to seaweeds or allied structures in the neighbourhood, on the one hand, and on the other, by its affording complete aeration, abundant supply of food, and security to the little architects and their delicate plumes.

II. Polypides.

The rounded cavities and canals of the semitransparent cœnœcium contain numerous opaque masses (the polypides) and large ova slightly attached by their peduncles. The former often occur in groups, each individual, however, except in the case of buds,

[1] *E.g.*, Edicularium.

being perfectly free, and at liberty to wander anywhere along the chambers or externally through the apertures. In some cases they are packed closely together in the cavity, probably from external causes acting after immersion in spirit; for thin partitions, bridles, and pillars of the semitransparent cœnœcium often separate the individuals. The cavities are generally clean, though occasionally a little mud containing sponge and other spicules, including peculiar reticulated fragments apparently of Radiolarians, occurs. This would seem to show that currents of sea-water sweep through these chambers very freely, probably assisted by the active movements of the cilia covering the tentacular plumes. Moreover, in dissecting out the latter, an operation performed with ease, owing to the friability of the cœnœcium, at first sight it may almost be supposed than an ovigerous envelope containing embryos is before us, so remarkable is the profusion of eggs and animals, and apparently so active is the reproductive function. The aspect of the adults and their terminal buds, the proportionally large size of the ova, and other features, however, negative such a supposition.

Each adult polypide (and they are somewhat uniform in size) measures, from the extremity of the cephalic plumes to the tip of the pedicle, about two millimetres (woodcut, fig. 2); and of this length the body-proper—that is from the buccal disk to the posterior bulbous region above the pedicle,—is rather more than one millimetre. The body in most is bean- or kidney-shaped (Pl. II. fig. 1), generally more rounded and bulbous posteriorly, since there is a tendency to a forward curve behind the pedicle. The dorsal surface is smooth and convex, a distinct constriction, however, being usually evident just behind the anterior region bearing the brownish-red pigment-spots. The latter region is generally bulbous and prominent, and in many a slightly elevated median ridge leading to the arms is present. So far as the spirit preparations go, therefore, the external differentiation of the anterior region, called "thoracic" by Lankester in *Rhabdopleura*, is indistinct in *Cephalodiscus*, but internally the collar body-cavities are diagnostic. As the pedicle is often curved forward or projected outward at a small angle to the body, the ventral surface is thus rendered comparatively short (Pl. III. fig. 2); indeed, in those which are much bent, the base of the pedicle touches the buccal disk. This contour of the body is interesting in relation to the oblique direction of the cup-like body of *Loxosoma*. When

FIG. 2.—Ventral view of *Cephalodiscus dodecalophus*, M'Intosh.

the pedicle is extended (Pl. III. fig. 1) the ventral surface is nearly straight and continuous with the pedicle, which leaves the body posteriorly at the ventral edge, while the kidney-shaped mass of the body projects dorsally. The pedicle in contraction is shorter than the body, is nearly cylindrical, and terminates in a rounded end; but in extreme elongation its appearance is much more attenuate. It is marked ventrally by various longitudinal striæ from the muscular bands.

The anterior region of the body curves somewhat suddenly downwards and backwards, and forms a flattened surface on which the great buccal disk or præ-oral lobe rests.

Buccal Disk.

The great buccal disk (Pl. II.; Pl. VI., fig. 2, *bs*) forms a thin plate with two slight and generally bilaterally arranged elevations in the centre anteriorly, and is divided into two regions by a notch at each side, the anterior moiety being the larger and thicker. The surface of the latter is marked by an arch of brownish pigment-grains, which are densest in the centre of the curve, and shade off gradually on each side; while a very conspicuous and well-defined deep brownish-red band commences in the posterior division at the notch, and runs with a backward curve to the opposite side. Between this and the posterior margin a brownish pigment-belt—less developed than in front—occurs. The two bands just mentioned form, when completed, a somewhat flattened ring. In many specimens, however, the brownish pigment has been entirely removed by the spirit, leaving only the well-defined reddish band posteriorly.

In intimate structure (Pl. VI. figs. 2, 3, *bs*) [1] the disk is found to consist of a ventral plate, the superficial characters of which have been described, and a pedicle. In section the former presents the features of a great hypodermic shield somewhat similar in structure to the Nemertean or Annelidan skin, and the surface of which in life is probably clothed with cilia, as indeed Professor G. O. Sars found in *Rhabdopleura*, though no distinct cuticular layer is visible in the preparations. This hypodermic tissue is marked in section by vertical striæ, which in the thick anterior central region assume a somewhat radiate aspect. The free parts of the shield present dorsally a firm basement-tissue under the cuticle, while ventrally, that is, on the secreting surface, the granular glandular tissue terminates in a translucent smooth edge. As the pedicle is approached, a narrow reticulated region appears within the basement-tissue strengthening the dorsal region of the disk, and the inner as well as the outer wall of this region assumes a firm structure—so as to resemble the basement-tissue. In the centre of the pedicle this region is traversed by a radiate series of muscular fibres, which spring from the firm tissue, constituting a kind of skeleton strengthening the basal part with which the plumes are

[1] I am much indebted to my assistant, Mr. John Wilson, B.Sc., for making a series of finely stained sections of *Cephalodiscus*. These have enabled me to determine features not fully seen in unstained sections made in cork by the hand.

connected. From this insertion they radiate into the thick central mass of the shield, and some appear to reach the pale ventral region of the hypoderm. Somewhat behind the former region the fibres also arise from the basement-tissue lining the hypodermic investment of the pedicle. This fan-like arrangement of the muscular fibres must confer great mobility on the disk, so that its broad scale-like surface can be applied either as a sucker or in an undulatory or partial manner, indeed enabling it to act as a useful locomotive organ. In this connection also it is probable that the basement-tissue may be highly elastic, especially in the absence of any signs of horizontal or transverse muscular fibres, and in connection with the entrance or exit of fluid by the proboscis pores. The glandular nature of the disk, again, shows that it is a structure with secerning powers of great activity, and in close relation with the remarkable cœnœcium. Superiorly the pedicle of the buccal disk runs into the region at the base of the arms, and in sections a fine layer of longitudinal and oblique muscular fibres occurs on the inner surface of the dorsal wall of the pedicle, though such have not yet been seen anywhere on the inner surface of the shield.

In the centre of the buccal shield is a large mesoblastic cavity through which the radiate muscular fibres before mentioned pass, and which communicates with the anterior by two well-marked pores situated dorsally on each side of the middle line at the great central nervous system. In oblique sections (*e.g.* Pl. VI. fig. 3, *bp*) these pores lie closely together in their progress inwards. What relation the ciliated "sense" organ of *Rhabdopleura*, as described by Sars, and also figured by Lankester, may have to the proboscis-pores of *Cephalodiscus* is a feature of moment for future consideration. In *Cephalodiscus* these pores seem to be formed by invaginations of the hypoderm of the region, but their function is as uncertain as the single pore perforating the nervous system in the proboscis of *Balanoglossus*. The organ in the latter is much more muscular and has an evident proboscis-gland.

While therefore the buccal disk of *Cephalodiscus* is in all probability the main organ of locomotion, just as in *Rhabdopleura*, which was seen by Professor G. O. Sars drawing itself up to the aperture of its tube, it differs from the shield of the latter by its much greater size.

In the form just mentioned the organ somewhat resembles the truncated and thickened opercular process of certain Annelids, while in *Cephalodiscus* it overlaps the neighbouring parts to a great extent. The intimate structure of the shield in *Rhabdopleura* has only been alluded to by Sars, and he does not appear to have clearly made it out. He says—"On examining more closely this buccal shield we observe in the middle of it an opaque part which seems to contain an interior glandular organ. Continuing the investigation and slightly pressing the animal, we notice, however, that this opaque appearance is not produced by any such internal organ, but by a peculiar and seemingly muscular structure of the shield itself. It exhibits, seen from below, in

the middle numerous small bubbles situated rather far from each other, or somewhat irregularly formed small cells, which, however, when more closely examined (and this is particularly evident in those which lie nearer to the periphery of the disc), show themselves to be external rounded extremities of small inwardly prolonged cylinders, which together appear to form a thick fascicle of incompletely differenced muscular fibres penetrating into the stalk of the buccal shield." He thus does not refer to the structure of the hypoderm of the disk, and yet this is one of its most important features, especially in connection with its functions. In all probability, however, it closely agrees with the hypoderm in the disk of *Cephalodiscus*, and the muscular fibres described by Sars no doubt arise from the basement-tissue connected with the lophophoral arms, and radiate in a fan-like manner into the hypoderm of the præ-oral shield. Further examination of *Rhabdopleura* would also appear to be necessary in regard to the presence or absence of a præ-oral cavity and proboscidian pores as seen in *Cephalodiscus* and *Balanoglossus*.

The buccal disk is apparently the homologue of the epistome in the ordinary Polyzoa, as Mr. Harmer affirms in the case of *Rhabdopleura*. It is also interesting to find paired spaces in the epistome of *Loxosoma*.[1]

The hypoderm of the buccal disk folds evenly over anteriorly to pass backwards and upwards to the pedicle, and as the latter is connected with the basal framework of the arms, this region forms the common ground for the origin of the twelve plumes.[2] On removing the disk, some of the plumes often remain attached to the pedicle, while others in the lateral regions are fixed to the basal tissue in front of the broad apron-like post-oral lamella on each side.

In transverse section the centre of the disk, even in early buds, presents a large median chamber, traversed by the radiate fibres of its muscular system, and communicating with the exterior through the pair of pores occurring in the region of the nervous system. It would thus seem that sea-water could be admitted into the interior, though, perhaps, this is by no means indispensable for the performance of its functions. Mr. Harmer has drawn my attention to the great similarity between the proboscis of *Balanoglossus* and this organ (buccal shield) in *Cephalodiscus*, though, it is true, only a single proboscis-pore leading through the nerve-ring of the stalk exists in the former, which likewise has a proboscis-gland and the so-called "heart." The functions of the organs differ very considerably, but there can be little doubt as to the nature of the interesting homologies between the two forms.

Branchial Plumes.

From the dorsal edge of the basal region just described, twelve plumes arise almost in linear series, six on the one side of the median line and six on the other. A thickened

[1] S. Harmer, *Quart. Journ. Micr. Sci.*, vol. xxv., N.S., pl. xx. fig. 18.

[2] Hence the name *dodecalophus*.

hypodermic area, with a median fissure, is visible in sections, and the pale region underlying this indicates the central nervous system. The hypoderm of the basal region contains numerous granular masses (gland-cells and pigment) which have a brownish hue by transmitted light. The plumes (Pl. II.) are nearly of uniform size, and consist of a thickish central stem, occasionally slightly crenate, and furnished with a series of longitudinal fibres ; while distally each is terminated by a peculiar bulbous enlargement, which at first sight resembles the tip of certain hydroid tentacles (*e.g.*, *Coryne* or *Syncoryne*) bristling with dart-cells and pigment. The rugose appearance, however, is due to large gland-cells containing granules and globules (Pl. V. fig. 1), which are arranged in a somewhat regular manner round a central cavity, and which present a deep yellowish tint in the preparations. This structure may perhaps be a further and special development of the somewhat large hypodermic granules of the tips of the pinnæ. The appearance of these bulbous enlargements in section is shown in Pl. IV. fig. 3, part of the upper wall of the stem in this case being formed of the ordinary hypoderm below the tip. When the latter is cut longitudinally, the space in the centre of the bulbous extremity is found to be continuous with a similar space at the end of the arm. Very soon, however, transverse bridles and fibres occupy the central region of the latter, so that a kind of meshwork takes the place of a canal. In transverse section the terminal region of the stem is formed of a thick coating of hypoderm (probably in life covered by a ciliated cuticular layer) somewhat regularly marked (Pl. IV. fig. 4) by striæ so that the cell-like divisions are frequently wedge-shaped. The hypoderm abuts on a basement-tissue, apparently continuous with that which belongs to the basal apparatus next the disk, and which is in relation laterally with the axes of the pinnæ on each side. The wall of the canal of the arm, even in this region, presents a series of fibres which render it hirsute in section, but they do not in every case meet across the lumen. As we proceed downward, however, the sections of the arms are flattened and the margins prominent, so as to form ventral grooves, and the two sides are bound together by transverse fibres, a median junction especially being conspicuous. This meshwork of fibres is better seen in good horizontal and longitudinal sections of the plumes, in which the transverse fibres pass from side to side in almost parallel series, minute nuclei or corpuscles being everywhere abundant, apparently adhering to the fibres, or perhaps indicating their origin from cells of the connective tissue. As in the basal region, therefore, the centre of the arm is composed of a series of reticulations or meshes. The hypoderm also of the arm below the terminal region is considerably thinner, showing that this system of lacunæ reaches its culminating point in the terminal enlargement. The longitudinal fibres inside the basement-tissue are probably those observed in the external views of the arms.

The sides of the stem (Pl. IV. fig. 1) are rendered plumose by a large number of long slender filaments having rounded or slightly bulbous extremities, which present a linear streak from base to apex, due to the axis or skeleton. The latter was first clearly

discriminated as a "skeleton" in *Cephalodiscus* by Professor Ray Lankester, for it had only been indicated as a septum in my preliminary account in the Annals of Natural History. The examination of fresh specimens of *Rhabdopleura* off the Norwegian coast had enabled him to detect the existence of a "consistent mesoblastic skeleton" in the lophophoral arms, as in *Phoronis*, and thus forewarned he had comparatively little difficulty in making out "a precisely similar skeleton" in *Cephalodiscus*. In the latter the so-called "skeleton" of the arms is fixed to the basal apparatus formerly described, and seems to consist of a somewhat firm basement-tissue with longitudinal fibres and reticulations in certain parts. It differs considerably from the condition as figured in *Rhabdopleura*, in which twisted filaments and particles are described by Lankester. The pinnæ which pass out from the main stem do not taper, and are composed for the most part of granular hypoderm with a few brownish pigment-cells, and the central axis or skeleton. The pigment gives in some a light pinkish or pale violet blush to the feathery plumes, which in life must have been finely tinted; and it is further interesting that the same pigment occurs in the lophophore of *Rhabdopleura*, as shown in Professor Lankester's excellent figures.[1] The skeleton (Pl. IV. figs. 1, 2*a*) runs from base to apex and terminates within the cellular tip. It is somewhat dilated where it joins the main stem (Pl. V. fig. 2, *sk*) and the exact mode of its junction with the axial channel of the latter is difficult to trace, so gradually is it merged into the tissues of the region. No definite ending of these axial structures occurs as in *Rhabdopleura*, where Professor Lankester figures them as if articulated to the skeleton of the arm, the base of the pinnules dilating, and the central region abruptly terminating, as it reaches the main stem. The dilated bases of the skeletal rods of the filaments in *Cephalodiscus* join the sides of the reticulated main channel, but no evidence of a continuous central lumen is observed in transverse sections of the free portions, though the double outline, and the appearance of sections of their bases (Pl. V. fig. 2), would indicate the possibility of such. Endosmosis at least would thus readily occur. In the transverse sections of the bases of the processes just alluded to a series of apertures appears in the tissue of the arm. The condition as described in *Rhabdopleura* therefore differs from that in *Cephalodiscus*, especially in regard to the skeleton of the arm, though the general plan of structure is similar. It would also appear to be more readily made out in the former than in the latter, though perhaps this may be partly owing to the examination of fresh examples. Professor Lankester describes the skeleton in *Rhabdopleura* as cartilaginous, but so far as appearances go in *Cephalodiscus* it more resembles a structureless translucent basement-substance, probably of a chitinous nature. It was best followed in the preparations immersed in a weak solution of caustic potash.

The skeleton of the arms and their pinnules gives a definite character to the processes, as observed in the sketches. Though perfectly mobile, the pinnules stand out from the

[1] *Quart. Journ. Micr. Sci.*, vol. xxiv., N.S., p. 621.

stem somewhat stiffly, the curves being for the most part terminal, and thus they do not mix with each other in an inextricable manner. In the same way the beautiful plumes of the Sabellidæ and *Phoronis* have a certain amount of rigidity from their internal skeleton, while their graceful motions and their branchial functions are in no way interfered with.

No special muscular apparatus can be made out in the pinnules, the covering of the central axis consisting of hypodermic cells and granules. Nor would such be necessary in regard to the physiology of the organs, the elasticity of the skeletal axis and its connection with that of the main stem being sufficient to keep the parts in a position suitable for their functions without any effort on the part of the animal. The main stem has a series of longitudinal fibres, but their muscularity is doubtful. In any case the motions of the disk would influence that of the entire lophophoral apparatus, especially as its great fan-like muscles arise from the skeleton of the basal apparatus of the arms.

The bases of the arms are hollow and in communication with the two great cavities (one on each side) of the region (Pl. VII. fig. 3, *cv*) which Mr. Harmer, on good grounds, identifies with the collar-spaces of *Balanoglossus*. In section the basal spaces are generally filled with fibres detached from the walls, but in some views definite corpuscles in groups are visible. The latter consist of minute rounded bodies with a central nucleus. From the structure of the parts it will thus be apparent that though probably pervious none of the arms show a clear median channel except at base and apex. The paired cavities connected with the lophophoral apparatus communicate with the exterior by a well-marked and comparatively large pore on each side in front of the gill-slits. These pores present a radiate arrangement of the hypodermic wall in transverse section and thus are readily recognised; while in certain longitudinal sections a more or less urceolate aspect is produced.

The tentacles of *Loxosoma* are stated by Professor Vogt and others to be devoid of a central chamber, and the central axis of the same organs in *Pedicellina*[1] is only cellular (and translucent). Even in *Rhabdopleura* careful examination under most favourable circumstances by Professor Lankester gave no indication of a median canal, even in the main stems. He was unable to detect any definite cell-structure in the skeletal tissue, but observed that it had a refringency indicating a certain density, and presented small twisted filaments and particles within its substance at intervals. The relation of the twisted filaments to the fibres described in the main stem of each plume in *Cephalodiscus* is a subject that requires further investigation, and the same may be said of the "particles" which occurred at intervals—in relation to the nuclei already described. Whether *Rhabdopleura* shows any indication of the lacunæ at the base of the lophophore is a question also requiring determination, though if such had existed it could hardly have escaped, in the living animal, two observers of such experience as Sars and Lankester.

[1] *Vide* Nitsche, *Zeitschr. f. wiss. Zool.*, Bd. xx. p. 22, Taf. iii. figs. 1, 2.

The arrangement of these numerous tentacular plumes differs considerably from that in *Rhabdopleura*, in which only two symmetrical tentacular arms with their pinnæ occur. In certain young buds, however, in which the first pair of plumes far surpass the others in length, a striking resemblance is temporarily produced to the condition in *Rhabdopleura*. The latter and *Cephalodiscus* diverge from the ordinary Polyzoa in this respect, both having mobile plumes that curve gracefully in various directions, instead of the somewhat stiffish corona and straight tentacles of the other forms. In *Cephalodiscus*, besides in all probability branchial functions, they are apparently of great tactile service, and if covered with cilia, as in all likelihood they are, they must aid in providing currents in the cavities of the cœnœcium, and, as Sars and Lankester suggest, may indirectly cause food-currents, that is, bring the minute particles which constitute the nourishment of the species within reach of the currents between the buccal shield and the post-oral collar. The efferent currents again would readily find exit by the gill-slits behind the latter lamella. Both *Rhabdopleura* and *Cephalodiscus* differ from the ordinary Polyzoa in the absence of the tentacular web at the base. Both have very long pinnæ; but *Cephalodiscus* excels the other in this respect, and is further characterised by the remarkable glandular tips to the arms. The plumes are wholly absent as such in *Balanoglossus*, and this constitutes a marked distinction externally. As formerly stated in regard to *Phoronis*,[1] however, there are certain evident homologies between the several forms.

Post-oral Lamella.

In *Rhabdopleura* Sars described "a strongly projecting, nearly semilunar border of skin, ciliated on its edges," and extending from the base of the tentacular arms downwards on each side, thus forming with the buccal shield a narrow half-tube or channel leading to the mouth, through which the nourishment is probably conveyed to the mouth by the ciliated tentacles. The condition in *Cephalodiscus*, however, considerably diverges, since the post-oral lamella (Pl. II. fig. 1) forms a flattened apron-like process, fixed anteriorly to the ventral surface behind the eyes, and sloping along this margin backwards to the mouth, the surface gently merging into the mucous membrane of the oral cavity. Moreover, a central space—more or less distinct according to the line of section—occurs between its layers. Laterally and posteriorly it forms a somewhat free lamella. In minute structure this lamella presents two layers of hypoderm, each with a fine basement-layer, and having intermediate fibres, chiefly muscular. A strong series of these passes out from the basement-tissue of the post-oral mucous membrane, and radiates to the outer (ventral) layer of the lamella, for the posterior or dorsal has merged into the mucous membrane at the sides. The hypoderm of the two surfaces just mentioned offers certain differences, especially in the free part of the lamella (Pl. VI.

[1] *Proc. Roy. Soc. Edin.*, 1880–81, vol. xi. p. 217.

fig. 2, *pl*; Pl. VII. fig. 5, *pl*), that covering the ventral surface being denser and more finely granular, and with a more definite margin, which is probably richly ciliated. This denser and somewhat regularly streaked hypoderm (which also stains more readily) shows several prominent frills or rugæ where it joins the oral region, and it just turns the outer edge of the lamella all round and then ceases. The dorsal layer of hypoderm on the other hand is more lax, and is thrown into a series of frills or crenations in the preparations, the streaks in it being more conspicuous than the granules. It resembles, indeed, the somewhat lax hypoderm observed on the pedicle, and like the latter contains numerous pigment-corpuscles which do not readily stain. So far as the structure can form a guide, the ventral surface would seem to be more important functionally than the dorsal.

The oral region therefore has a different environment from that in *Rhabdopleura*, though the plan of structure follows parallel lines. Thus in the excellent figures of Lankester,[1] a well-marked plate situated behind the mouth, and running into the buccal disk in front of it, is apparently the homologue of this lamella. When the disk is folded backwards (*op. cit.*, fig. 2) the two surfaces come more or less into contact, and would thus send currents more surely into the mouth. Lankester does not allude to this region, which lies just in front of his thoracic division in *Rhabdopleura*. In the flattened surface of the post-oral lamella the buccal shield is closely applied in the preparations, though in life they can of course be separated at will, thus permitting the currents caused by the cilia of the opposed surfaces to reach the oral aperture. As its posterior face has perhaps only to perform the function of separating the currents connected with the mouth from those of the gill-slits, the differences in structure are thus explained.

The post-oral lamella may have some relation to the Molluscan foot, and also to the post-oral ring of cilia in *Polygordius*, especially as a ciliated groove in the latter runs between it and the mouth. Harmer's view that it is homologous with the operculum of *Balanoglossus*, as described in Bateson's valuable and suggestive papers[2] on this form, appears to be well founded.

Digestive System.

Mouth.—The margin of the oral lamella leads on each side (Pl. III. fig. 3; Pl. VI. fig. 2, *m*) into the mouth, and in some ventral views it passes straight inwards to the sides of the latter, and forms a transverse margin anteriorly. The edges of the mouth are slightly raised or frilled laterally and posteriorly, the latter often being spout-shaped.

[1] *Op cit.*, pl. xxxviii. figs. 1, 2.

[2] *Quart. Journ. Micr. Sci.*, April 1884, Studies from the Morph. Lab. Univ. Camb., vol. ii. part i., and vol. iii. part i. The author has overlooked some remarks previously published in this country on *Balanoglossus*. *Vide* Nemerteans, *Ray. Soc.*, 1873, p. 144.

Anteriorly it is devoid of any well-defined boundary other than the attachment of the pillar of the great buccal shield, and leads directly upwards into the alimentary canal (Pl. III. fig. 1, *m*). Moreover, as Mr. Harmer first noticed in his sections, a solid diverticulum proceeds upwards dorsally into the stalk of the buccal shield, and this may fairly be held to be the homologue of the notochord of *Balanoglossus*. In transverse section it is nearly circular and presents a somewhat regular arrangement of its cells, so that a concentric appearance is frequently present. In longitudinal section, on the other hand, the process, which is small, has a slightly bent clavate outline, a dotted axis indicating the lumen continued from the alimentary canal. The mucous membrane of the buccal chamber and gullet are thrown into many prominent rugæ, from the dense glandular nature of the tissue. The latter is especially thick on the ventral side of the mouth (the region lying in front of the post-oral lamella), and a strong layer of muscular fibres passes to the basement-tissue of this region, which must thus possess considerable mobility. The surface of the mucous membrane is apparently richly ciliated, the cylindrical epithelium of which it is composed being so closely arranged as to give a finely striated character to the tissue. In some preparations a thin film occurs on the surface of this glandular tissue, but this is evidently due to mucus, and not to the separation of a superficial or cuticular coat.

Pharyngeal Region.—Beneath the post-oral lamella and immediately behind the pores of the second region are a pair of gill-slits, which were first clearly recognised as such by Mr. Harmer, who has kindly interested himself in the structure of this form, and whose very thin sections enabled him to unravel certain points which would otherwise have been obscure. The folds leading to these in transverse section are shown in Pl. VI. fig. 2, *gs*. Immediately behind the collar-pores the ordinary hypodermic coating of the body becomes continuous with the translucent wall of the slits, which seems to be a modified continuation of the pharyngeal mucous membrane. The granules are finer, and the whole tissue is more translucent. It also does not stain so well as either the collar-pores or the pharyngeal lining proper. In connection with this structure it is interesting to note that Bateson[1] mentions that the gill-slits in *Balanoglossus* arise as dorso-lateral evaginations. As soon as the posterior boundary of the mouth is completed, and this is easily recognised in the preparations by the appearance of the pigment-cells in the dorsal layer of the hypoderm of the post-oral lamella as it now stretches right across the ventral surface, the spacious pharynx presents a thickly folded wall of the same kind of minutely glandular tissue. The projection of some of these thick folds of glandular tissue under the post-oral lamella, sometimes causes peculiar appearances in transverse section, as if special diverticula existed. Bounding this thick glandular wall externally is a firm basement-layer, probably of a highly elastic nature, and it is to this coat that the muscular fibres formerly alluded to are attached.

[1] *Op. cit.*, p. 14.

Œsophagus.—The firm and finely glandular œsophageal region (Pl. III. fig. 3, a little behind *œ*), which is characterised by the paucity of its folds, is comparatively short, for it merges into the gastric chamber a little behind the termination of the buccal shield (Pl. III. fig. 3).

Stomach.—The stomach forms a large cavity, which in some instances fills the whole of the body-space, with the exception of the dorsal area occupied by the intestine. In certain longitudinal sections the œsophagus forms a comparatively limited tube, while the stomach fills the entire body-cavity (Pl. III. fig. 3), but dorso-ventral flattening of the former may have occurred in such cases. The wall of this region is also somewhat thick, and when fully formed, is distinguished from the œsophageal region by its more numerous and often symmetrical folds, and sometimes by a differentiation into three pseudo-strata, viz., a deeply stained, granular, epithelial, superficial layer marked by close parallel striæ, a pale intermediate region with granular glands, and externally another deeply stained stratum of granular glands. It is not implied that there is separation in continuity between the three regions indicated, but rather that either from preparation or otherwise such a condition appears in the stomach. The colour of this region in life is probably as characteristic as in *Rhabdopleura*, where it is yellowish, but this feature could not be made out in the spirit-specimens, for all are bleached. In the preparations it not unfrequently happens that rupture of the alimentary wall occurs along the middle region, so that the complexity of the folds in the body-cavity is increased. Externally the whole organ is surrounded by a firm basement-layer continued from the œsophageal region, and from its elasticity this probably subserves certain of the functions of a more elaborate contractile apparatus, for muscular fibres have not been clearly determined. The chamber narrows posteriorly towards the pedicle, and terminates in the intestine, the glandular wall, however, undergoing no change of note.

In *Rhabdopleura*, Sars[1] mentions that the stomach has tolerably thin walls, but in all probability he speaks comparatively, as from the nature of the glandular tissue such organs have proportionally thick walls.

Intestine.—As in *Rhabdopleura*, the stomach terminates at the posterior end of the body-cavity at the base of the pedicle by a wide aperture in the intestine. In favourable sections (Pl. III. fig. 3), the intestine is observed to leave the ventral side of the fundus of the stomach, and passing under it, curve forwards along the dorsal wall. The glandular lining of the ventral wall of the stomach passes evenly into the intestine and gradually diminishes in thickness, whereas the lining of the posterior wall shows a characteristic bend at the pylorus, and again a fold in the anterior wall of the intestine behind the fundus (Pl. III. fig. 3, near *vtd*). This peculiar fold in the wall of the canal probably indicates a tendency to the formation of a second or pyloric stomach, as in *Phoronis*, and is therefore of considerable morphological significance. The intestine

[1] *Op. cit.*, p. 5.

acquires its narrow firm texture even before the appearance of the forward curve along the dorsal wall. The latter forms a somewhat large canal, which proceeds along the dorsal wall above the stomach to terminate on the anterior prominence of the body in the anus, which lies considerably above the region of the plumes, and, indeed, the area in which the large pigment-spots are situated intervenes There is thus a decided difference when the anal region is contrasted with that in *Rhapdopleura*, in which the anus is situated close to the base of the tentacular arms on the dorsal side of the animal, that is, on what Sars terms the posterior region. Lankester, however, in his figure[1] shows the anus elevated on a rectal cone, with a depression between it and the base of the lophophoral region; and, moreover, on the lateral and ventral faces of this cone isolated blackish pigment-corpuscles are present. No rectal cone is present in *Cephalodiscus*, for the prominent anterior end of the body carries the anus on its summit. It has the form of a more or less elliptical aperture, often of considerable size. The minute structure of the wall of the intestine differs considerably from that of either gullet or stomach by its well-defined boundary line—both externally and internally. The external consists of the firm basement-layer, which ventrally bounds the stomach, and which at each side of the usually elliptical or transversely elongated gut (in section) runs into a thinner basement layer bounding the canal dorsally within the proper wall of the body. The granular glandular coat which follows is narrow, and is limited internally by a remarkably definite margin in section, so that the canal is at once distinguished in the preparations. In Professor Lankester's section[2] of the intestine in *Rhabdopleura*, no such compact and definite wall is observable, the gut apparently being enclosed by a somewhat moniliform layer of cells. This divergence in structure doubtless indicates difference in function, probably in relation to the free and the fixed conditions of the respective animals. The terminal region of the gut (or rectum) frequently shows considerable dilatation, the indigestible debris being probably sent out at intervals in a stream, and it is this deposit which is occasionally found in certain crevices of the cœnœcium.

Food.—A survey of the fine muddy debris found in the alimentary canal, and especially in the intestine, shows that the currents—set up in the surrounding water by the plumes, and conveyed towards the oral aperture by the ciliated surface of the post-oral lamella and the great buccal disk—carry inward, amongst indigestible sponge-spicules and sand-particles, many Diatoms, bodies resembling minute Thalassicollidæ and other Radiolarians, as well as organic particles of various kinds. When large forms like the Ascidians flourish on a diet composed largely of Diatoms, it is evident that this minute type is amply cared for in this respect. The honeycombed condition of the cœnœcium,

[1] *Op. cit.*, pl. xxxviii. fig. 2, *b*, and pl. xl. fig. 11, *e*.
[2] *Op. cit.*, pl. xli. fig. 13, *h*.

and the multitude of external apertures, thus suffice to place the little ciliated animals in favourable circumstances as regards food, especially when the nature of their surroundings is taken into account.

Body-wall.

In *Rhabdopleura* two layers of the body-wall were clearly distinguished by Professor Allman, who had not the material aid which sections give the younger inquirers. He called them ectocyst and endocyst, the latter "a very delicate membrane." Professor Sars, again, with fresh specimens at his disposal, denied that there was any endocyst "(unless we consider the glassy skin, which closely surrounds the digestive apparatus, to be an endocyst), consequently also no perigastric fluid." Professor Ray Lankester again, from the examination of living examples, recently observes of *Rhabdopleura* that "the tissue which bounds the body-cavity consists of fusiform cells tapering into fine fibres, sometimes branched." He further figures the structure of the body-wall in optical and in transverse section, the coat formerly mentioned having within it apparently a basement-membrane with ciliated enteric cells projecting from its inner surface. In whatever way this form is considered, the structure of its body-wall very much differs from that of *Cephalodiscus.*

I am unable from the mode of preparation of the examples (in spirit) to say much about the pigment of the surface of the skin, but in some numerous specks of a reddish-brown colour are still visible over the entire surface (Pl. II. fig. 1); while, as already mentioned, the buccal disk almost always presents the dull reddish band. In all probability it is brightly tinted in life. In this respect it approaches the condition in *Balanoglosus, e.g., Balanoglossus kowalevskii* has a white proboscis, a brilliant red-orange collar with a whitish line round the operculum, while the rest of the body is orange-yellow.

Externally the surface is probably covered in life by a delicate ciliated cuticle, but this cannot be differentiated in the preparations. The same difficulty is met with in the cuticular tissues of the Nemerteans. A decided difference is thus apparent between *Cephalodiscus* and *Loxosoma,* in which the cuticle is considerably developed. What remains is a well-marked layer of hypoderm (Pl. VI. fig. 2, *hp*) of the usual granular, glandular structure. The coat just mentioned attains its greatest thickness at the base and on the pedicle, but this may be partially due to corrugation from contraction. In this layer are the numerous pigment-corpuscles and gland-cells, which latter do not readily stain with carmine. It is bounded internally by a basement-layer, which is thin dorsally, but better marked ventrally, especially behind the mouth, for the layer of longitudinal muscular fibres now forms an additional coat in this region, and rests against the basement-layer. Like the hypoderm the latter passes over the pedicle at the posterior end of the body, and both are often thrown into wrinkles from contraction. The body-wall

is further strengthened ventrally by a muscular layer, but this will be described under its special head. The preparations showed traces of what might be an epithelial layer on the inner surface of the before-mentioned basement-tissue, but such were far from being distinct. In the living *Rhabdopleura*, on the other hand, such an epithelial layer is described by Professor Lankester, under the name of "enteric epithelium," and its distinctness in this form suggested its presence in *Cephalodiscus.*

Body-cavity.—The foregoing layers enclose the body-cavity (*co* in sections of buds), which is generally filled more or less completely by the alimentary canal. In the preliminary account[1] it was pointed out that this investment was probably homologous with the "thin glassy skin" of Sars surrounding the digestive canal in *Rhabdopleura*, and that the preparations gave no evidence of perigastric fluid. Though the existence of a body-cavity was not specially noticed, the preparations did not warrant a denial of its presence in *Cephalodiscus*, as Professor Lankester states in a recent paper,[2] for thus the hypoderm and basement-tissue must have been amalgamated with the coat of the alimentary canal, which was not the case. This statement does not in any way detract from the credit which Lankester has in clearly describing for the first time the chamber in the living *Rhabdopleura.* Small nucleated corpuscles were occasionally seen in groups in the cavity of *Cephalodiscus* in the sections, but they may have been introduced from other sources. Neither Sars nor Lankester observed such in the living *Rhabdopleura.* In sections the continuation of the body-cavities in front are seen a little behind the paired cavities connected with the lophophoral apparatus, and are likewise surrounded by basement-tissue.

Muscular System and Pedicle.

As previously mentioned, the short ventral surface of the body is continued into the cylindrical pedicle, which is invested by the hypoderm and basement-tissue, the former being thrown into numerous and rather regular transverse wrinkles in contraction, and being thicker dorsally than ventrally. At the terminal region of the foot (Pl. VI. fig. 1, *hps*) the hypoderm is much increased in thickness, but has the same structure. It is free from the wrinkles which characterise other parts of the region; and appears indeed in favourable preparations to form a flattened sucker-like disk. The basement-layer within the terminal hypoderm is thick, and has attached to it the longitudinal muscular bands, so that it is possible it may be occasionally used as a sucker like that of *Loxosoma*, or like the larval organ in *Balanoglossus.* The entire pedicle within the basement-tissue is filled with the longitudinal fibres, which arise on the ventral wall of the body in the region of the mouth, where they present the form of a thinner lateral region and a denser central, the latter in

[1] *Op cit.*, p. 344. [2] Polyzoa, Ency. Brit., vol. xix. p. 436.

the preparations being somewhat semicircular and of considerable thickness. These fibres pass backwards (causing the ridge on the ventral surface in contraction) towards the pedicle, which they enter, filling the central space. In transverse section the appearance of the latter varies, but in the best preparations a certain uniformity is observable (Pl. IV. fig. 5), viz., beneath the uniformly rounded hypoderm a median fold occurs in the basement-tissue dorsally, while a much larger and wider one occurs ventrally, and at each side of this an inner longer and an outer shorter process exist. The whole has a symmetrical appearance. Such an outline would indicate that the basement-tissue was elastic and that no circular muscular fibres existed, and indeed from the descriptions of Vogt and other authors similar elastic tissues subserve the function of circular fibres in *Loxosoma*. In some sections of unstained examples the thick basement-tissue had a somewhat different aspect (Pl. VII. fig. 2), probably from the condition after immersion in spirit; this, however, was exceptional. A layer of fine longitudinal fibres lies on the inner surface of this coat, and from it numerous transparent and somewhat gelatinous fibres of connective-tissue pass to the central area, which contains large structures deeply stained and almost resembling gland-cells, but which appear to be sections of the long mobile muscular fibres continued from the fundus of the body into the pedicle. The close approach made by these to the "muscular band of closely-set fusiform cells" described by Lankester in the stalk of *Rhabdopleura* is noteworthy; they probably represent a further development of that tissue—in which the cells have disappeared. A similar series of muscle-cells in the axis of the stalk is described by Harmer in his valuable paper on *Loxosoma*.[1] In contraction the transverse wrinkles of the basement-tissue are so close that they resemble a circular muscular coat.

No distinct canal is thus observed in the centre of the pedicle throughout its length. Towards the tip, however, certain spaces containing what appears to be a coagulable fluid occur, and also globules and granules, as explained in connection with the buds.

The pedicle in *Cephalodiscus* is thus evidently a development of the body-cavity, which in the young bud freely opens into its upper region. It differs, therefore, from the soft stalk of *Rhabdopleura*, first so clearly described by Professor Allman, for that has no connection with the body-cavity in the adult; yet as the development of both forms is unknown a little reservation is necessary, especially as it also contains muscular fibres in *Rhabdopleura*, and gives rise to the buds and branches. The fibres of the stalk in *Rhabdopleura*, according to Professor Sars, proceed "rather high up on the ventral side," and "over the skin which encloses the digestive apparatus. Its ventral fibrous part may still be traced (see fig. 15) a considerable distance forward in the form of a rather wide, clear, skin-border which gradually disappears in front of the cardia. In this skin-border the fine longitudinal fibres may still be distinctly observed diverging like radii, but I was not able to trace their course further."[2] The arrangement of the parts

[1] *Op. cit.*, p. 19.

[2] *Op. cit.*, p. 10.

in *Rhabdopleura* has also been carefully figured on a larger scale from life by Professor Lankester.[1] There are thus interesting points in analogy between the two forms in regard to the polypide-stalk, but at the same time important structural differences.

Professor Lankester again holds that the chitinous covering (his Caulotheca) of certain parts of this region is the true homologue of the cœnœcium of an ordinary Polyzoon, and there is something to be said in favour of such a view. As already explained, however, I prefer to adhere to the term already in use, especially in the present uncertainty in regard to the development of the types under consideration. Nor do I fully share my friend's views concerning the "serious error" of confounding the pedicle in the forms just mentioned with the funiculus of the Eupolyzoa. The structural relations of the organ in the several forms no doubt differ, but the remarkable analogy in regard to the budding shows that from the "vagrant protean funiculus" of the Gymnolæmatous Ectoprocta to the pedicle and soft stalk of *Cephalodiscus* and *Rhabdopleura* there is at least one striking function carried out often on very similar lines. Variations it is true occur, in which the endocyst is associated with the funiculus in producing the buds in the marine Ectoprocta, but this does not affect the main point at issue, but rather brings the analogy closer with such forms as *Cephalodiscus*.

The pedicle on the other hand nearly resembles the stalk in *Loxosoma*. There is no pedal gland, however, in *Cephalodiscus*.

One of the most remarkable points of resemblance between *Cephalodiscus* and *Balanoglossus* is the occurrence of a pedicellate structure in the young of the latter (*Balanoglossus kowalevskii*) as described by Mr. Bateson.[2] This organ presents itself on the disappearance of the cilia as a small papilla, and is situated at the central part of the posterior surface. Moreover, it is directed ventrally, just as the pedicle of *Cephalodiscus* is, and, indeed, the general contour of the young form at this stage simulates the condition in *Cephalodiscus*. This conical process serves as a sucker by which "the animal can attach itself to foreign bodies sufficiently firmly to prevent being washed off by a stream of water from a pipette. The anterior surface of the proboscis is also slightly suctorial, and by thus fixing itself posteriorly, and extending the proboscis, it is able to creep slowly about, somewhat in the manner of a leech." The organ "subsequently attains a considerable size and is traversed by several wrinkles. It afterwards entirely disappears, but as to its mode of disappearance I have no certain observations. It would appear to occur very suddenly at the stage when the animal possesses seven to eight gill-slits. I have found animals with eight gill-slits which possess this sucker, and also animals of apparently the same age without it; hence it may be inferred that it undergoes a rapid atrophy at this point." Mr. Bateson further observes that similar suckers occur as larval organs in Tunicata, Ganoids and Amphibia, but these fall far short of the

[1] *Op. cit.*, pl. xl. fig. 12.
[2] *Quart. Journ. Micr. Sci.*, Stud. Morph. Lab. Univ. Camb., vol. iii. part i. p. 3, pl. i. figs. 1–4, 1886.

interest connected with the condition of the permanent pedicle in *Cephalodiscus*. This is a truly homologous process of the posterior body-cavities, and in sections at the base, as already explained, the septum is visible (*vide* Pl. V. fig. 4). It is further placed ventrally in regard to the intestine, and its tip, so far as structure shows, is in all probability also used as a sucker; indeed, the buccal shield and the tip of the pedicle form far more efficient and permanent sucking disks than ever occur at any stage in *Balanoglossus*. It is the disappearance of the "tail" in the latter which alters the character of its reproduction, and confines it so far as known to the sexual process. The presence of this organ in *Cephalodiscus*, again, and its striking activity in bud-formation, open up new fields in homology and assist in bridging over the gaps which formerly existed between apparently isolated groups.

Nervous System.

In the preliminary account of *Cephalodiscus*[1] no distinct nervous system was observed. In *Rhabdopleura* all that the careful observations of Sars could distinguish in regard to a nervous system was that "immediately behind the anal aperture, between the terminal part of the intestine and the dorsal wall of the gullet, which here forms a little concavity, there appeared a clear cellular body (fig. 15, *r*) in which several evident nuclei were visible. I cannot, however, pronounce any decided opinion as to the significance of this object; it can scarcely be a nervous ganglion, as it does not lie in the substance of the body itself, but only in the thin external skin which encloses the body." Lankester, again, considers that it is probable that the "clear cellular body" just mentioned by Sars may be a gonad. It is doubtful, however, whether the latter interpretation can be maintained, especially when the condition now known in *Cephalodiscus* is considered. At the base of the plumes in the latter, and situated over the median space existing there—above the mouth—is in section a region (Pl. VI. fig. 3, *nc*; Pl. VII. fig. 3, *nc*), which appears to me to contain the central nervous system of the animal. The area is of considerable proportional size, and is minutely cellular and granular, while fibrous bands stretching from it occur in other views. Its inner face rests on the thick basement-layer bounding the collar-spaces at the base of the arms, and to the opposite wall of which the muscular fibres of the great buccal disk are attached; while its outer covering is formed by a thick layer of hypoderm. This region forms an elevation dorsally between the bases of the arms (Pl. VI. fig. 3, *nc*), and thus is in close communication with these organs, while it is also within a short distance of the pigment of the oviducts, though no branches have been traced to these organs. It extends a considerable distance laterally on each side along the basal region, whence the plumes spring, and for some distance on the dorsal surface of the buccal disk. The relations of the nervous system to

[1] *Ann. and Mag. Nat. Hist*, ser. 5, vol. x. p. 337, 1882.

the rudimentary notochord will be specially referred to by Mr. Harmer in a note appended to this paper. The view of Professor Sars that this structure cannot be a nervous ganglion, because it does not lie in the substance of the body, would not seem to merit the importance he attaches to it, when the condition of the great nerve-cords and ganglia of Annelids, for instance, are considered. These are purely hypodermic in position, lying between the latter and the basement-layer beneath.

In *Phoronis*, again, a somewhat similar condition to that in *Cephalodiscus* is present, the nervous concentration taking the form of a ring round the mouth at the bases of the tentacles, and which, like the cord running along the foot, is epidermic (hypodermic) in position.[1] The same position (hypodermic) of the nervous system is found in *Balanoglossus*, so that the relations of the nerve-centre are by no means exceptional.

The position of this nervous centre would not appear to correspond with the larval brain of *Loxosoma* as described by Mr. S. Harmer. In the stalked or adult *Loxosoma*, again, the organ is absent, a condition due, Mr. Harmer thinks, to the fact that the larval form dies after giving off buds. A very different condition, however, occurs in *Cephalodiscus*, in which the young buds soon present this and all the other organs of the adult, although it is true the development and perhaps metamorphoses of the species from the egg are unknown. It has also to be borne in mind that certain parts of the central nervous system may have been suppressed, and that we may have only a much modified peripheral system remaining.

Sense-Organs.

In the preliminary account of *Cephalodiscus*, the close relation of the so-called eye-spots to the ovaries was duly pointed out, and recently the examination of more satisfactory sections made with a microtome demonstrated at once their true nature; viz., that they are oviducts with thick pigmented walls. The resemblance of these structures, both externally and in section, to a modified organ of sight, is one of the most remarkable features in the animal. Their description will be given subsequently.

In *Rhabdopleura*, Lankester mentions the occurrence of five spherical pigment-corpuscles at the superior dorsal margin of the buccal disk, and regards them as rudimentary sense-organs for the perception of light. The position of such is certainly peculiar for organs of vision, but if *Rhabdopleura* has a trace of the central nervous organ observed in *Cephalodiscus*, these would readily be within reach of its communications.

It is interesting that eyes occur in most larval *Loxosomæ;* indeed, they make their appearance when the larva is still in the egg. They are situated under the hypoderm, and resemble pigment-masses. In *Loxosoma leptoclini*, for instance, Harmer describes a pigment-spot on each side of the larval brain (even when the lumen is still present after involution). They consist of crescentric reddish-brown masses of pigment, with a

[1] Caldwell, *Proc. Roy. Soc.*, vol. xxxiv. p. 372.

prominent lens, but whether the latter is a solid body, a cuticular formation, or only fluid in the centre of the mass, is not explained. Mr. Harmer bases one of his arguments for the interpretation he has given of the "dorsal organ" (brain) on the constant relation to each other of ganglion-cells, a fibrous layer and the eyes, and he seems to have facts in his favour.

In *Rhabdopleura* a ciliated tubercle (considered by Lankester and others to be a sense-organ) was discovered by Sars on the dorsal surface at the base of each arm of the lophophore. In *Loxosoma* also Vogt[1] describes a tactile papilla on each side near the arms, and Salensky[2] traced nerves from the ganglion to these posterior sense-organs in *Loxosoma crassicauda*. No such organs, however, can be observed in the preparations of *Cephalodiscus*, though it is possible the search in the living animal might be more successful. The oral folds of glandular tissue and the parts connected with the gill-fissures are probably highly sensitive and ciliated, but no other sense-organs could be observed.

Reproductive Organs.

No differentiation was noticed in regard to the sexes, and no dimorphism of the zoïds, as in Professor Ehler's remarkable burrowing form (*Hypophorella expansa*[3]). Nothing is more striking, however, than the profusion of buds and the abundance of ova, apparently one of the chief ends of the species being propagation. The chambers of the cœnœcium present many of the large ova, and they are occasionally found amongst the plumes, as in *Phoronis*, with its swarms of minute eggs; but such in the former is probably accidental; and almost every adult bears one or more buds attached near the tip of the pedicle.

Ovary.—In most specimens a pair of large ova are observed projecting anteriorly (Pl. III. fig. 2, *ov*), so that their pure white colour is recognised through the attenuated integument above and behind the eye-like oviducts, which, as it were, mark the anterior boundary of the ovary. In section it is found that a septum passes from the median wall of the rectum to the opposite wall of the body, thus dividing the body-cavity in that region into two spaces, in which are the ova supported on a pair of lateral mesenteries. As soon as the glandular tissue forming the dorsal wall of the buccal cavity appears, the mesenterial septum just indicated is attached to its basement-layer externally, and also more or less in the median line. The septum disappears on the approach of the stomach, or about the posterior termination of the great buccal disk, and any product remaining towards the end of the latter is generally pushed to one side. As a

[1] Sur les Loxosoma des Phascolosomes (sep. copy), p. 8, pl. xii. fig. 1.

[2] *Ann. d. Sci. Nat.* (Zool.), sér. 6, t. v. p. 12 (art. 3), pl. xii. figs. 2, 3.

[3] *Abhandl. d. k. Gesellsch. d. wiss. Göttingen*, 1876.

rule anteriorly one of the spaces contains a group of small ova (Pl. VI. fig. 2, *ov*), with nucleus and nucleolus. In the smallest ova observed the nucleus is very distinct, and of a more or less rounded form and with a large nucleolus. The yolk outside the former is minutely granular, and sometimes, to judge from the preparations, does not quite fill the egg-capsule. As the eggs increase in size the yolk-granules become somewhat more distinct, the nucleus being large and rounded, and the nucleolus a highly refracting circular body of considerable size. Moreover, as they increase they tend to move away from the smaller ova, and indeed bulge outwards on the opposite side. The largest ova, of which, as a rule, there is only one, are much more coarsely granular, and present only a nucleus with minutely granular contents, the nucleolus having disappeared or having become very indistinct. The capsule surrounding each of the eggs is definite and tough, and the eggs are further enveloped by a common layer, which in all probability is allied to the follicular layer in fishes and other types, and this dips between each, apparently enclosing the ova in separate chambers. The ova are probably extruded through the oviducts with the pigment in their walls, and it is noteworthy that, as Mr. Harmer has specially pointed out to me, no pigment is visible in young individuals in which the ovaries are not yet functional. There is thus an approach to the condition in *Loxosoma* in this respect, for the latter has oviducts for conveying the ova into the vestibule. The same may be said with regard to *Phoronis*, though in this the so-called nephridia lie on the other side of the intestine.

The comparatively large size of these ova recalls the condition in the Artisca, in which the great ova produce embryos about a third the size of the adult.

Oviducts and Pigment.—On the ventral surface are two large and conspicuous pigment-spots, which as already mentioned closely resemble eyes: they indeed give a most peculiar and characteristic aspect to the animal when viewed from the ventral surface. These are placed a little in front of the anterior margin of the post-oral lamella, and in ordinary preparations are more or less covered by the buccal disk. They are circular or irregularly rounded, and of various shades of brown or reddish-brown, with occasionally a tinge of violet. In ordinary views from the exterior these organs show a pale centre surrounded by a broad margin of pigment, so that the former assumes the aspect of a lens (Pl. VI. fig. 2, *od*). In section the hypoderm in the central region is hollowed more or less deeply, and its wall presents a finer, columnar arrangement of its cells, and, in addition, it is almost, if not quite, transparent. Moreover, an aperture exists in the centre, as already mentioned. In shape the ducts have the form of a blunt cone, the apex of which abuts on the modified hypoderm, while its base rests on the small anterior ova. The pigment-cells form a thick layer; their inner pale portions projecting internally, so that their resemblance to an optical apparatus is remarkable. Nothing intervenes between their cavity and the ovigerus envelope, and indeed, as formerly stated, they are so closely

related that they are generally removed together in dissection. No nerve-fibres could be traced from the central organ to these organs, though appearances were favourable to such a view. Mr. Harmer, who independently arrived at a similar conclusion with regard to the function of these organs, thinks the pigment of an excretory nature.

On extrusion the ova (Pl. V. figs. 5, 6) are pure white, and either pyriform or rounded in shape. Each is provided with a well-formed pedicle of the transparent investment, truncated at the extremity for attachment. The diameter of the circular kind is about $\frac{1}{46}$ inch, or including the short stalk $\frac{1}{40}$ inch. In the more pyriform or longer forms the total length (including the stalk) is about $\frac{1}{36}$ inch, and the transverse about $\frac{1}{50}$ inch. The diameter of the contained yolk is about $\frac{1}{70}$ inch in the former kind, and in the latter is nearly of the same proportional size, though more ovoid in outline. A large space (perivitelline) existed around these eggs, but whether endosmose had occurred after deposition, or otherwise, is at present unknown. The capsule is hyaline and structureless, presenting only a few wrinkles at the base of the stalk, which is hollow and truncated at the tip. The opaque white central region is coarsely granular, as in the intra-ovarian eggs. Each is attached to the wall of the chamber of the cœnœcium by the pedicle, though as now seen, that is after the action of spirit, many have become detached.

The products of the foregoing ova are yet undiscovered, though in all probability they are motive embryos which carry the species to fresh sites on which to construct the cœnœcium. Such embryos had all been swept out of the chambers either before or after capture, as no trace of such could be found in the preparations.

The reproductive organs seem to be more largely developed in this genus than in *Rhabdopleura,* none indeed having been found in the latter by its discoverer, Professor Allman, or subsequently in the living examples by Professor Sars. Professor Lankester, however, was successful in finding a testis in "the form of a much elongated sac ending blindly at one end and opening by the other to the exterior by a special pore." The latter occurs near the anus. The position of the aperture of the male generative system thus probably indicates what will be found in the living *Cephalodiscus*, and it is possible that the male organs are developed at a different period from the female in the same animals, or that the males exist in different colonies. In some of the sections of the reproductive organs minutely granular masses like sperm sacs were occasionally seen, but further examination gave no grounds for supposing that they were anything but imperfectly preserved contents of the ovaries.

Budding.

No feature is more striking in this species than the great abundance of buds throughout the entire series of adults inhabiting the cœnœcium. Very few exist without them, most

presenting from one to three or more buds at various stages, and in all cases these proceed from the terminal region of the pedicle.

The early buds consist of minute and, in the preparations, somewhat pale clavate or pyriform bodies attached by the narrow end to the pedicle. They are situated round or near the tip (which has the thickened investment), and are observed as little processes projecting from the hypoderm. They appear to rise close above the terminal disk, and, in their earlier stages at least, seem to have a channel of communication with the pedicle of the adult (Pl. VI. fig. 1, *ch*). This channel runs upwards along the stalk of the bud as far as the downward bend of the hypoderm (shield) where it is lost. In the earlier buds longitudinal sections, for an examination of the best of which I am indebted to Mr. Harmer, show, very clearly the three regions of the body, viz., shield, nuchal region and body-proper, and each has its special spaces. Thus the shield presents its single cavity, the nuchal or collar-region its paired spaces, and the third region contains the body-cavity divided by the mesenteries (dorsal and ventral).

Very soon the pedicle is differentiated from the disk; the young animal consisting of a large, flat, and somewhat thick disk, and a short, broad and somewhat crenate pedicle attached to the parent. Two ovoid opaque thickenings are observed about this stage dorsally (Pl. V. fig. 3, *lp*), and these are the earliest indications of the lophophoral plumes. In cross section from above downwards the shield consists of a thick layer of hypoderm which attains its greatest development ventrally, for this coat is in the form of a flattened ring round the central chamber. The latter is bounded by a firm investment of basement-tissue having fibres internally. It is this chamber in the younger forms that communicates with the pedicle of the adult. The two dorsal bosses are simply hypodermic growths of the upper layer of the shield, and present an elevation between them.

At a somewhat lower level the elongated cavity in the centre of the shield gives place to a rounded median chamber (Pl. V. fig. 3, *vc*), with the dorsal hypodermic mass above it; while the great bosses of the plumes lie on each side. The latter still present the same structure as the hypoderm of the broad disk, though there is a faint indication of a linear streak in the centre. In the next slice the two nuchal or collar-spaces appear, with the alimentary canal in the centre. In the septum, between the collar-spaces, the tip of the notochord is observed, and it appears to be larger proportionally in the young than in the adult. The basement-tissue bounding the nervous centre is now defined, and the shield and bosses are diminishing. Behind this the folds of the alimentary canal fill the central region of the body, the intestine being especially distinct as a median canal, the longest axis of which is directed ventrally instead of being transverse as in the adult. Posteriorly the body presents, firstly, two lateral chambers with fibres internal to the basement-layer, and secondly, a median (dorsal), with a process of basement-tissue running to the ventral line, and forming the septum between the two former. The pedicle seems to be filled with muscle-cells.

In the terminal region of the pedicle of the adult certain areas containing a coagulable fluid with globules and granules are present, and occasionally in the elevation caused by a developing bud one or two of them are observed; and they are also seen in the buds here and there in the course of the central muscles of the pedicle. Some appear to be nucleated. The origin of these bodies is unknown, but they may be connected with the mesoblastic or hypoblastic elements for the buds, though this is only a conjecture. In regard to the presence of the three primary embryonic elements, as a rule, in such buds, the remarks of Professor Haddon[1] seem to me to be very interesting, but they have yet to be proved. The doubt remaining in the present case, for instance, relates to the precise nature of the hypoblastic elements. In connection with this subject it is well to state that some observers, as Mr. Harmer, demur to the connection of the latter layer with the origin of the buds.

As development proceeds, the anterior or disk-bearing region of the body increases much more in proportion than the posterior or pedicellate part. The buccal disk is rapidly enlarged, and shows traces of the broad arch of pigment anteriorly and the reddish band posteriorly, as well as the two median elevations on the surface. The posterior moiety of the disk is especially large. Moreover, the body begins to project outward superiorly, and the papillæ of the plumes increase in number. These papillæ form a slightly curved row in front of the dorsal projection of the body (woodcut, fig. 2).

In the next stage the disk is almost completely formed, though of smaller size and more massive than in the adult. It is thickest anteriorly, much thinner posteriorly. In the former region it presents in transverse section the elongated central chamber, bounded ventrally by the massive hypoderm of the shield, which has the two median prominences observed in the adult. This hypoderm folds over at each side, and is continued as a thinner stratum dorsally, with a basement-layer next the chamber. Two additional structures have now appeared, viz., a dense (narrow) layer outside the basement-tissue just alluded to, and fan-like fibres from the middle of the dorsal wall of the chamber. Two of the most ventral plumes (the first to appear) have now attained some size, the tip being furnished with the radiate terminal glands, with the central chamber, and the sides with short papillæ representing the filaments. Both the latter and the axis of the plumes are composed of hypodermic tissue, and are apparently solid. Longitudinal striæ are visible along the centre of the axis, and they run into the lining of the cavity in the terminal enlargement. Then the central chamber appears dorsally in the middle line (Pl. V. fig. 3, *vc*), and the fibres to the ventral wall of the shield radiate out from the basement-tissue. Dorsally several less developed plumes also make their appearance (Pl. VI. fig. 4), and the pale (nervous) area lies under the hypoderm. Next the two nuchal chambers take the place of the former, and the hypoderm over the median

[1] *Op. cit.*, p. 34, &c.

nerve-area increases much in thickness, the whole forming a somewhat triangular region between the bases of the plumes, which are thus carried outwards. None of these plumes are so well developed as the first pair. While the nerve-area retains a large size, with the two chambers and the fan-like fibres ventrally (Pl. VI. fig. 5), the knife now severs the anus, which at this stage lies close behind the massive dorsal hypoderm of the nerve-area. Then the glandular wall of the buccal chamber and the post-oral lamella appears, while the body-cavity on one side of the rectum presents a granular mass (Pl. VII. fig. 4, *ov*), the rudiment of the ovary. The great buccal disk becomes much broader as well as thinner, and is solid, while a central chamber appears in the post-oral lamella. The body-cavity is much better marked in the young forms than in the adults, and just behind the mouth (Pl. VII. fig. 5, *r, vt, oe*) has in section a symmetrical arrangement of the gullet, stomach and intestine, the body-wall showing the basement-layer beneath the hypoderm. The pharynx, gullet and stomach are rounded or ovoid in transverse section, but the intestine is triangular. The longitudinal muscular fibres appear along the ventral wall immediately behind the mouth, and soon form the marked pattern so characteristic of the region (Pl. V. fig. 4, *co*). The body-cavity thus shows from above downwards the comparatively small intestine, now rounded, and the massive glandular wall of the stomach in the middle, both being surrounded by a firm investment which leaves what may be called the keel of the stomach to be attached to a pointed incurvation of the ventral wall. On each side of the latter is the thick central mass of the longitudinal muscles, which externally also present another increase before being lost on the body-wall. A considerable perivisceral cavity exists on each side of the digestive organs.

Behind the foregoing the body-wall becomes thicker and the central chamber less, especially as the stomach ends in the intestine. The ventral muscles have considerably increased in bulk, and the double inflection for the longitudinal muscles on each side of the median line more marked. At the curvature of the alimentary system in the body-cavity, the pedicle proper commences, the external wall having a proportionally thicker coating of hypoderm than the body-proper, and supported internally by the basement-layer, which forms the W-shaped pattern inferiorly with a secondary curve on each outer leg. The ventral half of the space is filled with the muscular fibres, while the rest is split into two divisions by the median septum continued from the alimentary canal. The sides of the septum and the inner surface of the wall are covered with fibres. The buccal shield extends backwards to this region in the form of a broad, thin lamella, having a median line of basement-tissue separating the ventral and dorsal layers of hypoderm, and so little has the pedicle increased in length, that in some cases the free posterior margin of the disk almost touches the pedicle of the parent to which the bud is attached. The pigment inthe disk now approaches the condition in the adult.

The body-cavity of the buds at this stage thus glides insensibly into the first part of the pedicle, but the brevity of the latter organ gives rise to rapid changes in section.

The next slice, indeed, shows the muscular fibres filling up the entire central area of the pedicle, while the septum proceeds only a short distance inwards from the dorsal wall. A somewhat radiate arrangement of the fibres also takes place, and is best marked ventrally in transverse section. After a short course the fibres terminate on the hypodermic covering of the end of the pedicle, which at this stage presents proportionally great development. The immature pedicle of the bud thus differs from that of the adult in the outline of the basement-layer, which is simply reniform in transverse section, whereas that of the adult presents two maxillæ on each side ventrally, and a median dorsal fold.

Externally, as indicated, the short pedicle almost immediately follows the anterior dorsal projection of the body; and as a peculiar curvature of the latter has now taken place, the tip of the pedicle scarcely projects beyond the margin of the disk. Shortly after reaching the stage just described, and while the symmetrical series of filaments on each side of the plumes is quite small, the bud separates from the parent. The pedicle and its sucker-like hypodermic termination are fairly developed; and as soon as it is detached (and sometimes before) a little bud appears near the tip. Thus the increase of the species by budding alone must be remarkable, even comparatively young forms giving rise to a succession of buds. One or two buds are most frequently seen on the pedicle of the adult, though occasionally three or more exist.

Shortly before obtaining freedom the buds in some cases present a striking resemblance to certain stages in the buds of *Rhabdopleura*, as shown by Professor Allman. Thus in examples in which the first pair of plumes are very long and the succeeding short, while the stalk is in a state of extension, a condition closely approaching Professor Allman's figure 8[1] is produced.

The buds thus differ from those in *Rhabdopleura* in attaining freedom on reaching a certain stage, but both probably arise in a similar way, two at least of the embryonic layers taking part in their production. The first layer is represented by the dermal layers, nervous centre, buccal region, and the rectum, and the second by the skeletogenous tissue and longitudinal muscles. The presence of the third layer, as already mentioned, is more doubtful, though it is possible that the cells and globules observed towards the end of the pedicle may be of hypoblastic origin, being derived from the central region of the alimentary canal. The sections of the younger buds present, in the arrangement of the alimentary canal, a close resemblance to the young *Pedicellina*, as shown by the careful researches of Dr. Barrois and Mr. Harmer. The position of the ganglion in the diagram[2] of the latter would nearly correspond with the nerve-centre in *Cephalodiscus*.

In *Loxosoma* the position of the buds is very different, viz., in the region of the stomach, and there are never more than two.

[1] *Quart. Journ. Micr. Sci.*, pl. viii.

[2] *Quart. Journ. Micr. Sci.*, pl. xxii. fig. 19.

Homologies.

Cephalodiscus approaches very nearly to *Rhabdopleura* in almost all the structural features, and it is probable, when more complete investigation of both is carried out, these resemblances will be increased rather than diminished.

Thus the *Cœnœcium* in both is largely developed and wholly independent of the polypides, while it is mainly secreted by the buccal shield or disk. The regularly ringed cylindrical cœnœcium of *Rhabdopleura* is, however, very different in form from the irregular, much branched and hispid cœnœcium of *Cephalodiscus*. Moreover, in the latter it is the secretion of the adults, whereas in *Rhabdopleura* much of it would appear to be the product of the younger buds. *Phoronis*, again, secretes its simple gelatinous investment in the sand, or in the form of tubes attached to stones or other foreign bodies, while an Australian species betakes itself to the gelatinous case of *Cerianthus*. There is thus comparatively little method in the formation of its isolated dwelling. *Balanoglossus*, on the other hand, has only a mucous lining to its perforation in the sand, though the secretion of this form is also very abundant. Moreover, Bateson describes a peculiar odour in the living animals, and the spirit-preparations of *Cephalodiscus* also give evidence of a characteristic odour, though it may differ from that of the former.

The general form of the polypides of *Cephalodiscus* and *Rhabdopleura* diverges very considerably, the former being free, while the latter is fixed by the axial stem. Both, however, are small, while the size attained by *Phoronis* is a distinctive feature, as also is the absence of a pedicle from its cylindrical body.

The *Buccal Shield* is much larger in *Cephalodiscus* than in *Rhabdopleura*, and its secreting powers more active. The buccal shield is absent in *Phoronis* as such, but is represented by the epistome. As will be pointed out by Mr. Harmer, the proboscis of *Balanoglossus* appears to be the homologue of the disk, though only one proboscis-pore is present, while two exist in *Cephalodiscus*. Further examination is necessary in regard to these organs in *Rhabdopleura*.

The *Branchial Plumes* have a kind of skeletal system or basement-tissue in both *Cephalodiscus* and *Rhabdopleura*, but they are much fewer in the latter than in the former, which, moreover, has a bulbous and glandular tip to the main axis, thus simulating such organs as the large eye at the tip of the branchiæ of *Branchiomma*. The large size and firm nature of the simple branchial filaments of *Phoronis* are sufficiently diagnostic, as also is the fine, double, convoluted arrangement seen in the Philippine and Australian forms. The skeleton and circulatory system of these organs is much more highly developed than in either *Cephalodiscus* or *Rhabdopleura*. In *Balanoglossus*, again, considerable divergence has happened, for the branchiæ are now arranged in lateral series along the second region of the body, and are supported by an

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The *Circulatory System* is evidenced only by the lacunæ (nuchal or collar spaces) and their connections with the bases of the plumes in *Cephalodiscus*, but it would appear to be more largely developed than in *Rhabdopleura*, for its presence has not yet been indicated in that form. The circulatory system in *Phoronis* attains a much higher degree of complexity, for its large vascular ramifications with the well-marked nucleated corpuscles have no parallel in either. *Cephalodiscus*, however, agrees in that its collar-spaces are in connection with the reticulated or lattice-like centre of the main stem in each plume. The circulatory system in *Balanoglossus*, again, is also largely developed, especially in connection with its branchial system, though the contents of the vessels are less conspicuous. On this head all the foregoing widely diverge from the ordinary Polyzoa.

The *Digestive Apparatus* in both *Cephalodiscus* and *Rhabdopleura* closely agrees with the type in the Polyzoa, all being characterised by the flexure which causes the close proximity of mouth and anus. Moreover, the pyloric differentiation indicated in *Cephalodiscus* is prevalent in the Polyzoa and also in *Phoronis*, and though it has not been described in *Rhabdopleura*, traces of it may yet be found. The environment of the mouth in the latter and *Cephalodiscus* is related, but while the post-oral lamella is connected with the buccal shield in *Rhabdopleura*, it forms a special structure in *Cephalodiscus*. In *Phoronis* the general plan of the digestive system is the same, though the pyloric region of the stomach attains much greater size. In regard to this system all the foregoing closely approach the Eupolyzoa, the œsophagus, stomach, pyloric vestibule, intestine and rectum showing a similar arrangement. When *Balanoglossus*,

[1] *Vide* Monograph on the Brit. Nemerteans, Ray Society, 1872–73, p. 146.
[2] Fresh-water Polyzoa, p. 36.
[3] *Zeitschr. f. wiss. Zool.*, 1871, Bd. xxi. p. 457.
[4] *Quart. Journ. Micr. Sci.*, 1883, vol. xxiii. p. 518.

however, is contrasted with them very considerable differences are encountered, one of the most decided being the straightness of the canal and its terminal anus.

The *Nervous System* is præ-oral in *Cephalodiscus* and it has a somewhat peculiar structure. It is situated between the hypoderm externally and the basement-tissue internally. None has yet been described in *Rhabdopleura*, and thus comparison at present must remain in abeyance. In *Phoronis* the nervous elements, which lie along the base of the branchial processes, are similar to those in *Cephalodiscus*, and there is also a central area between mouth and anus. The nervous system is subhypodermic, and is chiefly concentrated in the corresponding region to that in *Cephalodiscus*. So far as known, therefore, all have something in common under this head.

Unless the oviducts in *Cephalodiscus* are to be credited with remarkable functions, sense organs, so far as can be noticed in the spirit preparations, are absent. Further inquiry is necessary on this head, but I am inclined to consider with Dr. Marcus Gunn, on whose special experience and caution I place reliance, that there is no refractive mechanism. This localized pigment perhaps indicates either phosphorescent organs or local heat-producers. In *Rhabdopleura* a pair of ciliated pads or papillæ occur at the bases of the plumes, the minute structure of which, however, is in need of careful revision. *Phoronis*, again, presents only the ciliated furrows, which are external to the anus, and have a nervous expansion beneath the hypoderm. In *Loxosoma* papillæ similar to those just described occur on the dorsal aspect, and the subœsophageal ganglion is well developed, as shown in Harmer's beautiful researches on *Loxosoma crassicauda*.

The structure of the *Body-wall* in *Cephalodiscus* considerably diverges from that in *Rhabdopleura*, the definite layers of hypoderm and basement-tissue in this form contrasting with the cuticular epithelium and underlying connective-tissue cells in the latter. Something like basement-tissue seems to be indicated in Lankester's pl. xl. fig. 12 (though no mention of it is made), and he describes and figures the enteric epithelium lining the body-cavity, the cells being connected with the wall of the stomach by processes. The body-wall in *Phoronis* again deviates from that in either of the foregoing, since, besides cuticle, hypoderm and basement-tissue, it shows a circular and a longitudinal muscular coat, the latter being chiefly grouped in longitudinal bands which in transverse section show a somewhat pennate arrangement. There is little in common, therefore, beneath the basement-tissue, and the absence of the pedicle in *Phoronis* is a marked feature of divergence. The structure of the body-wall of *Cephalodiscus* most nearly approaches that of *Balanoglossus*, though there is a wide gap in this respect as there also is between it and *Phoronis*. In *Loxosoma* a transparent cuticle and a hypodermic layer "associated at certain points with muscular fibres more or less pronounced," according to Vogt are present.

Cephalodiscus and *Rhabdopleura* agree in certain respects in regard to the *Body-cavity*, but the former has the pedicle as an appendix. *Phoronis* on the other hand has

a much more spacious chamber divided by various mesenteries. In *Balanoglossus* this chamber posteriorly is inconspicuous in the adult. The condition again in the Entoproctous Polyzoa (*e.g.*, *Loxosoma*) considerably diverges, for no body-cavity exists; while in the Phylactolæmata it is present in the adult, and is lined by ciliated epithelium, such not being the case in the body-cavity of the Gymnolæmata.

It is an interesting fact that the *Muscular System* both in *Cephalodiscus* and *Rhabdopleura* is connected with the pedicle, if we may for the moment so term the soft contractile stalk of the latter. In the former, however, it is much more largely developed and is continued directly from the body-cavity; whereas in *Rhabdopleura* it is wholly external to that chamber, and is less distinctly differentiated on the surface of the axial skeleton, which forms another feature of distinction in this form. If the funiculus of one of the Eupolyzoa be disconnected from the digestive system and formed into an external process in the line of the ordinary communication-plate, something similar in structure and function to the pedicle in the Aspidophora will be made. As a rule in the same group the retractor muscles of the body and lophophore arise from the peritoneal lining.

The funiculus of the Eupolyzoa, according to Haddon, is probably derived from the irregular strands of funicular tissue which occur in the parent zoœcium. It appears as a thickish cord stretching from the fundus of the developing polypide to the base of the zoœcium. It is in direct communication with the brown body, directing "the developing alimentary tract to that nutritive mass, thereby ensuring the better nutrition of the growing bud." The bud is thus developed at a distance from the brown body, but approaches it and extracts nutriment from it. This has been noted by other authors. In *Loxosoma* the stem quite differs, since there is no communication with the body-cavity.

The present condition of our knowledge of the *Reproductive Organs*, both in *Cephalodiscus* and *Rhabdopleura*, is incomplete, so that a satisfactory comparison cannot be made. The ova in the former are very large, but no male elements have been seen. In *Rhabdopleura* the testis occurs as a long sac adjoining the intestine and even projecting beyond the abdomen. It opens near the anus, and thus agrees with the condition in *Cephalodiscus* and *Phoronis*, as well as offers certain resemblances to the condition in the Entoproctous Polyzoa. The reproductive organs in *Phoronis* are posterior in position, and both male and female elements are usually conspicuous. In *Balanoglossus* these elements occur between the liver and the anterior part of the body.

The early appearance of the ova in the young buds of the Eupolyzoa, for instance *Bugula flabellata*, as noticed by Haddon, is worthy of mention. These ova are in close relation to the wall of the digestive tract. The distinction of the Aspidophora from such of the Eupolyzoa in which the ova of the parent pass ready-formed into buds is marked.

Budding.—The fact that *Cephalodiscus* is free while *Rhabdopleura* is fixed causes considerable divergence in regard to the buds; and, moreover, the functions performed by the bud in the latter species, while yet incompletely developed, and with a bifid buccal shield (viz., the secretion of the cœnœcium or tubarium) is an important difference. Another essential divergence is the occurrence of the buds in a regular series on *Rhabdopleura*, the youngest nearest the terminal polypide, the oldest next the distal. The confinement of the buds in *Cephalodiscus* to the region just within the terminal hypodermic plate is peculiar, and makes it difficult to institute anything like parallelism between them in this respect. Further, Lankester is inclined to think that after the complete development of the polypide in *Rhabdopleura*, there is no evidence that it takes upon itself bud-production; that is to say, the buds are given off at an early period of its growth. It is not quite clear, however, that the budding of this form is in the same category as that of *Cephalodiscus*, in which the stalk is a process of the body-cavity, whereas the soft stalk of *Rhabdopleura*, if the descriptions are understood correctly, has not yet been shown to be so, though at first sight it might be interpreted otherwise. Nothing like the arrested buds of this form is known in *Cephalodiscus*. The source of the hypoblastic elements, if these are present, in the bud of *Rhabdopleura* is thus in obscurity. In *Phoronis* no bud is known, while the small ova are extremely numerous, and the embryos (having the form of the well known Actinotrocha) pelagic. In *Balanoglossus* likewise no bud occurs, the ova are numerous and small, and the embryo free-swimming (Tornaria).

On taking a general survey of the subject, then, it occurs to me that in the present state of our knowledge, and while fully admitting the remarkable resemblances between it and certain hitherto isolated types such as *Balanoglossus* (which I have for the most part left in the able hands of Mr. Harmer), it will lead to no disadvantage if *Cephalodiscus* be left as formerly near the Polyzoa; and, further, though the divergences between it and *Rhabdopleura* are noteworthy, in the same group as formerly, viz., the Aspidophora of Professor Allman. It is well to exhaust the structural, developmental, and other features in the various forms reviewed in the preceding paragraphs before changes in classification are promulgated.

Cephalodiscus approaches the Polyzoa in regard to its cœnœcium, its digestive system, and its buds, and it is peculiar that in these points there is a lack of conformity in *Balanoglossus*, and to some extent in *Phoronis*. Viewed as a whole, the several systems mentioned agree most with the type of the Polyzoa. Though *Phoronis* forms a tube, and *Balanoglossus* secretes very abundant mucus, a feature common to many diverse groups, such as the Nemerteans, Discophora, and Mollusca, nothing like the regular cœnœcium of *Rhabdopleura* or *Cephalodiscus* is constructed. While again the digestive system of *Phoronis* resembles that in the Polyzoa, the same system in *Balanoglossus* is very different, for the straight alimentary canal with its terminal anus has no

parallel in the life-history of *Cephalodiscus*, not even an embryonic approach occurring in either form. The anus in *Balanoglossus* is posterior and terminal at all stages. The relations of the dorsal and ventral surfaces in the two forms are also at variance. Buds again, are unknown in either *Phoronis* or *Balanoglossus*, and in both the eggs are very numerous and small, whereas in *Cephalodiscus* they are few and very large.

The main resemblances between *Cephalodiscus* and *Balanoglossus* lie in the structure of the skin, the presence of three body-cavities (disk, collar, and body-proper), the proboscis or disk-pores, collar-pores, gill-slits, and rudimentary notochordal structure, and they are of a most interesting and suggestive character; and as Mr. Harmer, whose valuable researches on the Entoproctous Polyzoa are well known, has most ably studied these features and formed independent conclusions, I have thought it best to give his views in his own words as an Appendix. These will show how difficult it is in some cases to draw clear lines of distinction—so intimately are the several characters, in apparently diverse groups, blended. In a former paper[1] I had observed with regard to *Phoronis* and *Balanoglossus*—"If indeed the branchial skeleton supporting the vessels (of *Phoronis*) were thrown in, and arranged at the sides of the anterior region of the body, so that the water would enter by lateral slits to aerate the circulating fluid, and the digestive canal enlarged and attached as a single tube to the body-wall, a form resembling *Balanoglossus* would be indicated." It has to be borne in mind also that Alexander Agassiz thought that the latter resembled the Tunicates from the nature of the gills and their mode of formation, in opposition to the views of Kowalevsky and others, who placed its affinities with the Annelids proper.

Perhaps *Balanoglossus* may at present be ranged near the Aspidophorous group of the Polyzoa, for though Metschnikoff's view that it approaches the Echinoderms rests on the remarkable fact that in Tornaria the original evagination from the gut is on the left side, just as in Asteroid larvæ the water-vessel is developed from the left primitive diverticulum (Bateson), yet there are stronger reasons for associating it with other groups as above mentioned.

[1] *Proc. Roy. Soc. Edin.*, Session 1880–81, vol. xi. p. 217.

APPENDIX.

By Sidney F. Harmer, B.A., B.Sc., Fellow of King's College, Cambridge, and of University College, London.

The following observations on *Cephalodiscus* were made in consequence of a letter received from Professor M'Intosh, calling my attention to certain remarkable features in the anatomy of the genus. I am very greatly indebted to Professor M'Intosh for his courtesy in giving me specimens of *Cephalodiscus*, and most of all for his kindly expressed desire that I should publish my conclusions as an appendix to his own monograph. Time has not permitted of my seeing the proofs of this monograph, and I must therefore claim indulgence for any descriptions which would otherwise appear unnecessary repetitions of the results of Professor M'Intosh himself.

In examining sections of *Cephalodiscus*, I have been struck with the existence of various organs which appear to me to point to the conclusion that this remarkable genus is a near ally of *Balanoglossus*. This very unexpected result will be understood by comparing the following woodcuts (with the remarks which accompany them) with Bateson's papers on the anatomy and development of *Balanoglossus*.[1]

Fig. 1 represents a longitudinal, right and left section, of a young bud of *Cephalodiscus*. The resemblance between this section and Bateson's diagrams of the larvæ of *Balanoglossus*[2] is, in all essential details, exact. The body of the young *Cephalodiscus* is divided, by means of two transverse grooves, into three well-marked regions. Of these the anterior (*p.*) may be compared to the proboscis of *Balanoglossus*; the middle division (*c.*) to the collar of the same animal, and the posterior division (*tr.*) to the trunk or body. It will further be noted that the proboscis is provided with an anterior, undivided body-cavity, the collar and the trunk each containing a body-cavity

Fig. 1.—*p.*, proboscis; *c.*, collar; *tr.*, trunk; *al.*, alimentary canal; *nch.*, notochord; *b.c.*[1], body-cavity of proboscis; *b.c.*[2], body-cavity of collar; *b.c.*[3], body-cavity of trunk.

[1] *Quart. Journ. Micr. Sci.*, vols. xxiv., xxv., xxvi.

[2] *Quart. Journ. Micr. Sci.*, vol. xxvi., pl. xxxiii. fig. 7.

which is composed of two halves separated by means of dorsal and ventral mesenteries. These five spaces are completely separated from one another, and their arrangement is in exact accordance with that of the corresponding sections of the body-cavity in *Balanoglossus.* The similarity of *Cephalodiscus* to the same animal is rendered still more striking by the existence in the former of a diverticulum (*nch.*) of the front part of the alimentary canal, extending a short distance forwards into the region of the proboscis, and homologous with the notochord described by Bateson.

The course of the alimentary canal is sufficiently explained by means of this figure.[1] The mouth (*m.*) is seen to be overhung by the large proboscis (*p.*), otherwise known as

Fig. 2.—Longitudinal section of an adult *Cephalodiscus*, supposed to be taken sufficiently on one side of the middle line to allow of the representation of one of the ovaries, and of one of the proboscis-pores. *p.*, proboscis; *stk.*, stalk; *m.*, mouth; *ph.*, pharynx or branchial region of gut; *œs.*, œsophagus; *st.*, stomach; *int.*, intestine; *a.*, anus; *nch.*, notochord (really visible only in a median section); *ov.*, ovary; *ovd.*, pigmented oviduct; $b.c.^1$, $b.c.^2$, $b.c.^3$, divisions of body-cavity as in fig. 1; *p.p.*, one of the proboscis-pores; *op.*, operculum; *n.s.*, central nervous system.

the epistome or buccal shield. The dorsal and ventral mesenteries are not visible, since the section is not exactly median. The third body-cavity ($b.c.^3$) is very large, and contains the alimentary canal and ovaries. The anterior body-cavity ($b.c.^1$) continues to form the lumen of the proboscis, whilst the relations of the collar-cavities are not quite those of the preceding figure. Dorsally the two halves of the body-cavity of the collar have extended forwards into the proboscis region, whilst ventrally they are to be found (apparently fused ?) solely in the post-oral lamella or operculum. The cavities of the proboscis and of the collar (and more particularly of the latter) are to some extent

[1] A fold in the intestinal region of the alimentary canal, of the existence of which I have been informed by Professor M'Intosh, has not been inserted in the diagram.

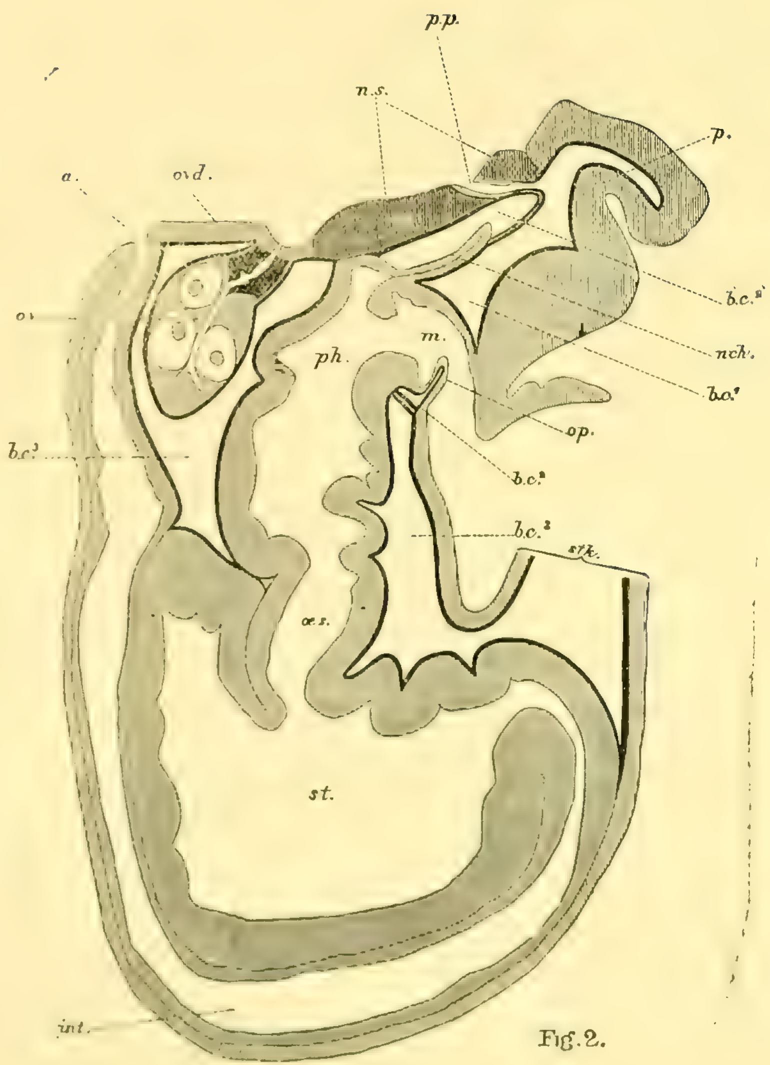
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Fig. 2.

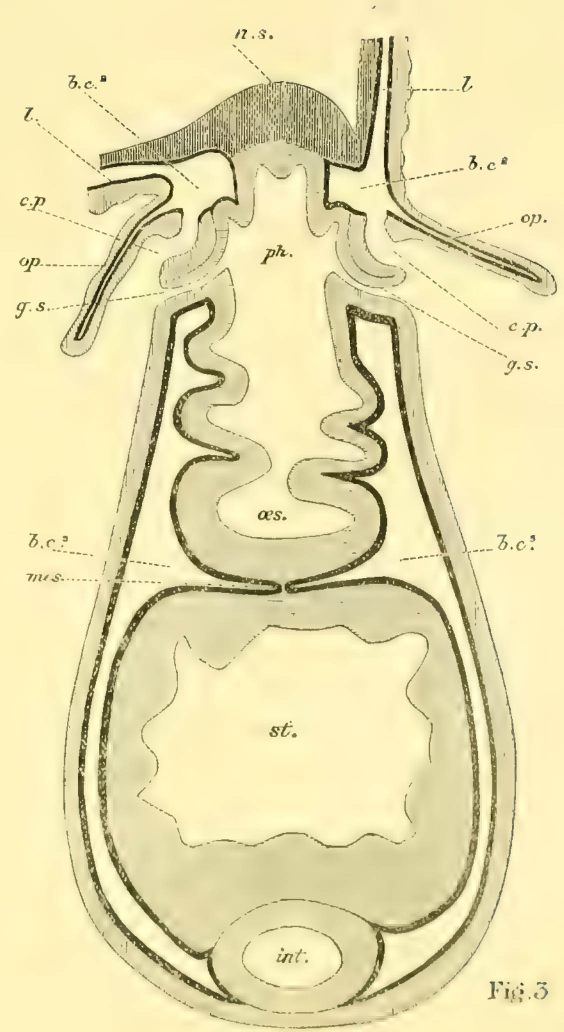
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Fig. 3

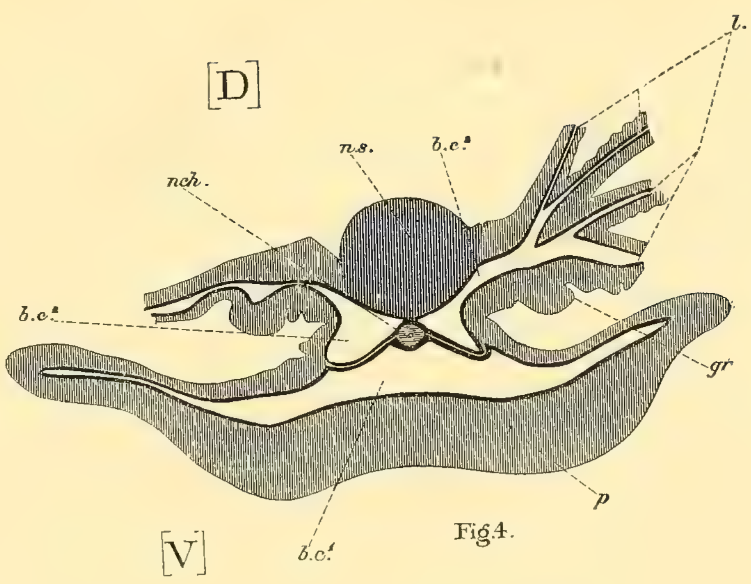

Fig.4.

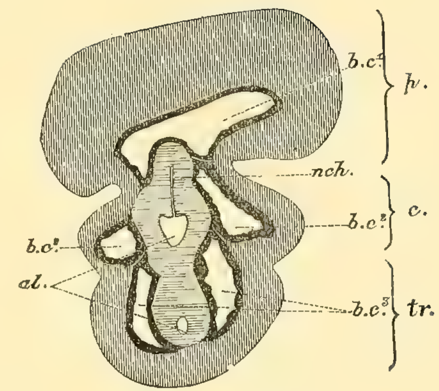

Fig.1.

The course of the alimentary canal is sufficiently explained by means of fig. 2.[1] The mouth (*m.*) is seen to be overhung by the large proboscis (*p.*), otherwise known as the epistome or buccal shield. The dorsal and ventral mesenteries are not visible, since the section is not exactly median. The third body-cavity ($b.c.^3$) is very large, and contains the alimentary canal and ovaries. The anterior body-cavity ($b.c.^1$) continues to form the lumen of the proboscis, whilst the relations of the collar-cavities are not quite those of the preceding figure. Dorsally the two halves of the body-cavity of the collar have extended forwards into the proboscis region, whilst ventrally they are to be found (apparently fused ?) solely in the post-oral lamella or operculum. The cavities of the proboscis and of the collar (and more particularly of the latter) are to some extent obliterated by muscles and connective-tissue. The notochord (*nch.*) has, in the adult, the form of a slender bar, provided with a fine lumen, stretching forwards in the proboscis-stalk into the proboscis itself. It is continuous at its base, as in the young bud, with the epithelium of the alimentary canal.

The further relations of the notochord will be described in connection with fig. 4.

The central nervous system is developed on the dorsal side of the collar as a mass of ganglion-cells and nerve-fibres lying outside the basement-membrane of the epidermis. It is, however, continuous anteriorly with a similar development of nervous tissue situated on the dorsal aspect of the proboscis, and laterally with a well-developed nerve-layer on the dorsal sides of the lophophoral arms. In the young bud, in which the collar is represented by a region of the body separated by transverse grooves from the proboscis on the one hand and the trunk on the other, the condition of the central nervous system as a development of the collar is particularly well marked, although even at an early stage a thinner nerve-layer occurs on the proboscis. In the adult, there is no sharp line between the nervous tissue of the collar and that of the proboscis. At about the level of the anterior end of the notochord, the nerve-layer is perforated by a pair of pores—apparently derivatives of the ectoderm, which pass from the exterior into the body-cavity of the proboscis (*p.p.*, fig. 2). These pores are disposed symmetrically with regard to the median plane of the animal, and are at no great distance from that plane.

In most species of *Balanoglossus*, it is well known that an asymmetrical proboscis-pore occurs on the left side, whilst in *Balanoglossus kupfferi*[2] two proboscis-pores are present. It is thus obvious that the proboscis-pores of *Cephalodiscus* are a further feature in support of the view that this animal is related to *Balanoglossus*, the disposition of these pores in *Balanoglossus kupfferi* being in this respect particularly noteworthy.

One of the two ovaries (*ov.*) is represented in section in fig. 2. The duct (*ovd.*) is

[1] A fold in the intestinal region of the alimentary canal, of the existence of which I have been informed by Professor M'Intosh, has not been inserted in the diagram.

[2] *Vide* Bateson, *Quart. Journ. Micr. Sci.*, vol. xxvi. p. 555.

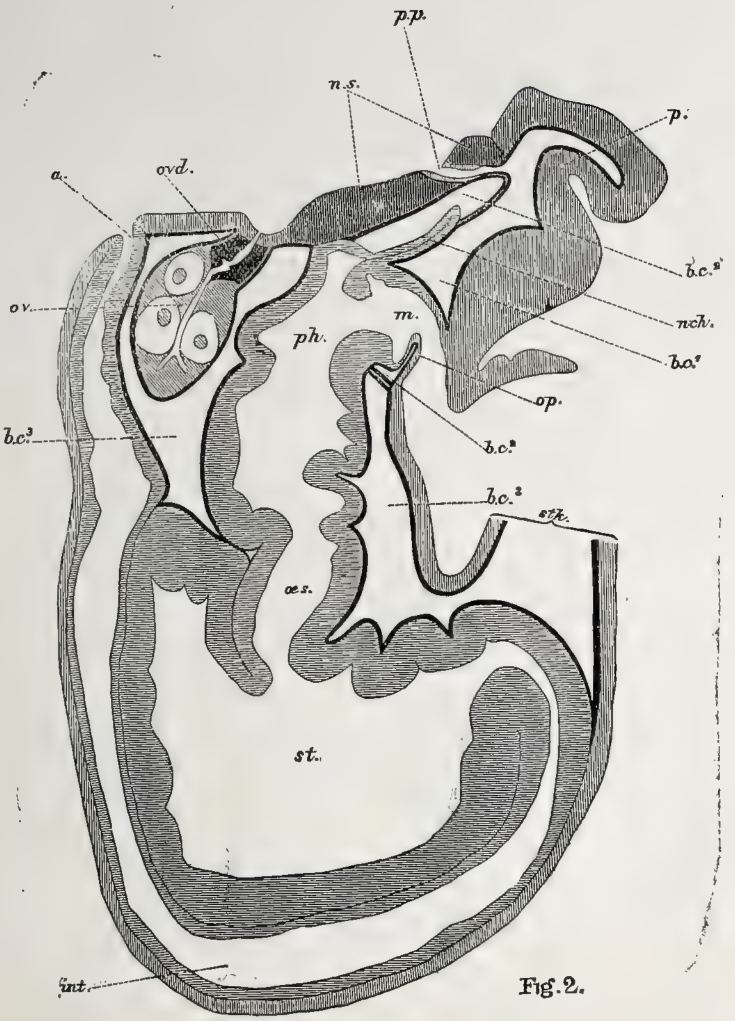

Fig.2.

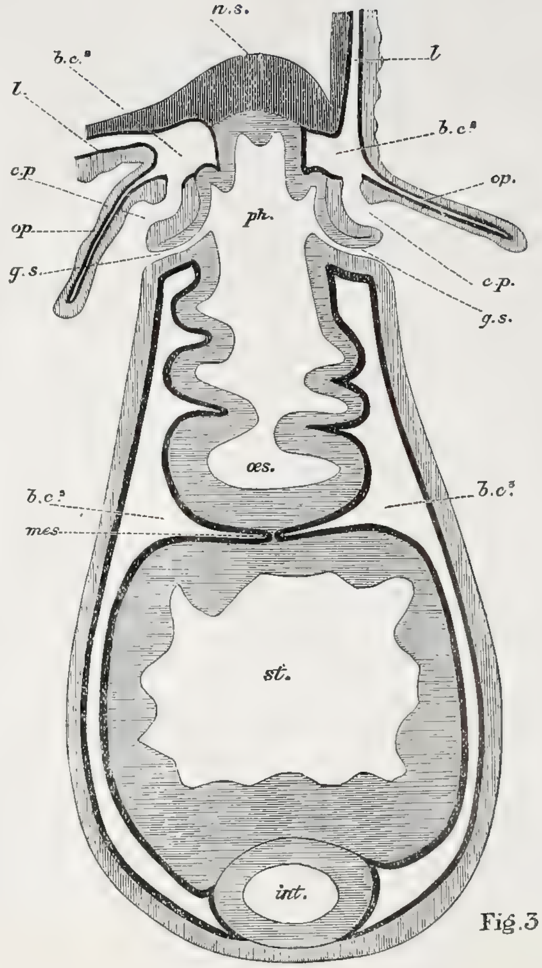

Fig.3

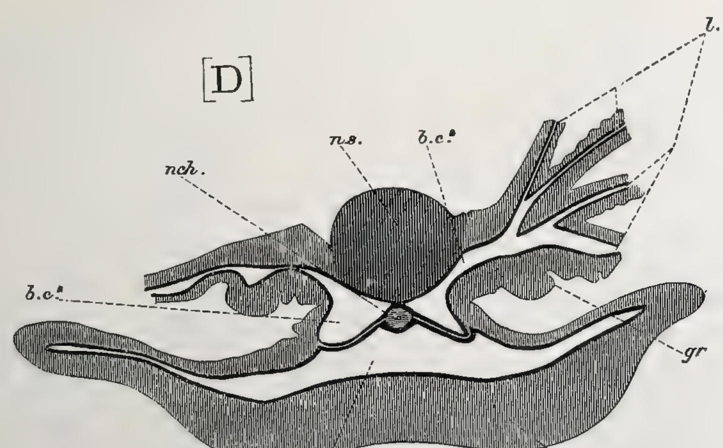

Fig.4.

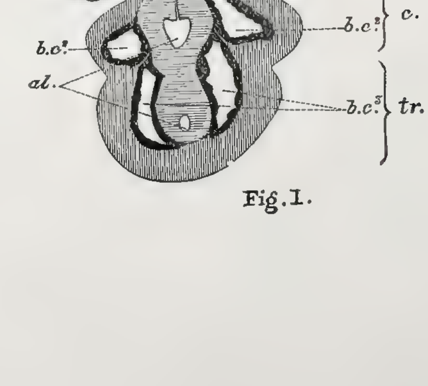

Fig.1.

of a rich brown colour owing to the existence of pigment in its walls; the oviducts have on previous occasions been described as eyes.

Fig. 3 will serve to illustrate the anatomy of the collar-region of *Cephalodiscus*. Whilst in the bud, this region is distinctly marked out by transverse grooves passing round the body of the animal, this distinctness is no longer visible externally in the adult form. The collar-region is, notwithstanding, no less sharply marked out internally than at younger stages. Its body-cavity ($b.c.^2$) is perfectly distinct from the remaining cœlomic spaces of the animal, although it is to a considerable extent (and especially in the lophophoral arms and the operculum) filled by loose connective-tissue (as in *Balanoglossus*). The dorsal part of the collar is produced on each side into six tentacular arms, into which (and into the individual tentacles) the collar-cavity may with ease be traced. The nervous system (*n.s.*) extends on to the dorsal face of each arm. The ventral border of the collar is produced into a free fold, the operculum or oral lamella, which reaches its highest development laterally and ventrally (with the exception of the median line in the latter region). It has before been stated that the collar-cavities extend, dorsally, for some distance along the proboscis region (*vide* fig. 2, $b.c.^2$), and as a matter of fact, the anterior limit of these cavities is coincident with the origin of the most anteriorly placed lophophoral arms. The collar is much less developed on the ventral side ($b.c.^2$, fig. 2), its cavity in this region being, however, continuous at the sides of the alimentary canal with the dorsal part. The posterior border of the collar passes on each side of the body along a line, which would be roughly indicated in fig. 2 by joining the posterior end of the nervous system, dorsally, to the base of the operculum, ventrally. This line corresponds, on each side of the body, with the origin of the oral lamella or operculum. Since fig. 3 represents a section taken near

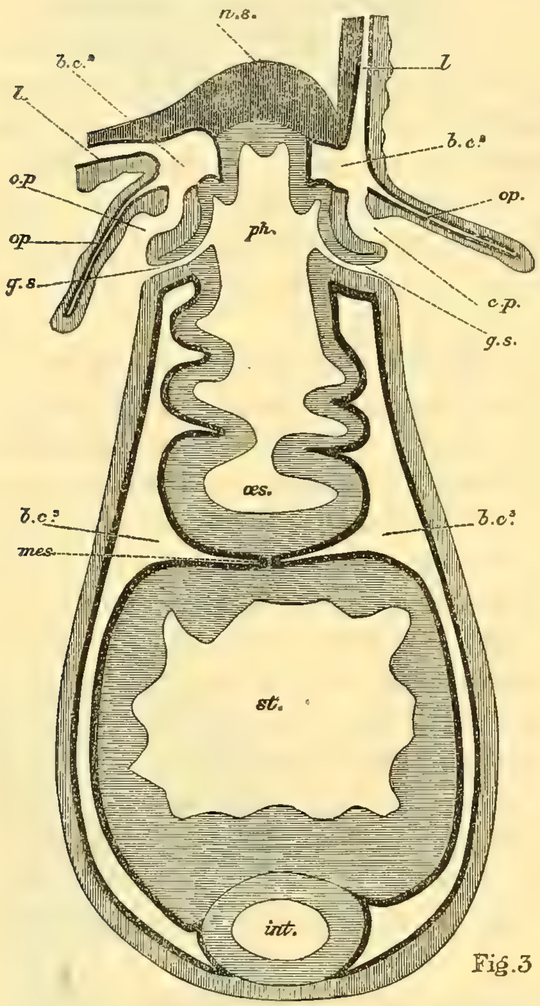

FIG. 3.—Longitudinal right and left section through an adult *Cephalodiscus*, passing through the pharnyx (*ph.*), œsophagus (*œs.*), stomach (*st.*), and intestine (*int.*); *n.s.*, nervous system; *l.*, lophophoral arms; *op.*, operculum; *c.p.*, collar-pores; *gs.*, gill-slits; *mes.*, dorsal mesentery; $b.c.^2$, body-cavity of collar; $b.c.^3$, body-cavity of trunk.

the posterior limit of the central nervous system, it is intelligible (from the relations of the base of the operculum just explained) that the operculum is seen, in the section, to spring from a region of the body quite near to the dorsal surface. It is, however, clear that the operculum is merely a free fold of the posterior border of the collar-region, containing a portion of the collar-cavity, and that it is therefore exactly comparable to the operculum described by Bateson in *Balanoglossus*.

On each side of the body is found a well-marked "collar-pore" (fig. 3, *c.p.*), consisting of a very short canal whose walls are formed of narrow, closely arranged epithelial cells, and opening on the one hand into the cavity of the collar, and on the other to the exterior, the external openings of the pore being overhung by the base of the opercular fold. Both in the structure and in the position of these canals, *Cephalodiscus* resembles *Balanoglossus* to an extent which is almost inconceivable, except on the hypothesis of some genetic connection between the two genera.

A further *Balanoglossus*-feature possessed by *Cephalodiscus* is the existence of a pair of well-marked gill-slits (fig. 3, *g.s.*) opening to the exterior immediately behind the collar-pores, and so far as I have been able to make out from an examination of the buds, apparently developed as outgrowths of the "pharyngeal" region of the alimentary tract. The relation of these slits to the collar-pores is precisely the same as that of the first pair of gill-slits of *Balanoglossus* to the collar-pores of the latter. Unlike *Balanoglossus*, *Cephalodiscus* possesses no more than a single pair of gill-slits, but it must be remembered that the young *Balanoglossus* remains for some time in a similar condition (*i.e.*, with but a single pair of gill-slits), and that Bateson has assumed the existence of an ancestor of *Balanoglossus* in which no metameric repetition of the gill-slits had taken place.

Fig. 4 illustrates the relation of the structures in the proboscis-stalk, which—as in *Balanoglossus*—is a constricted region by which the proboscis itself is connected with the rest of the body. The completely separated collar-cavities are clearly visible, as well as the unpaired proboscis-cavity. The notochord is a slender rod, possessing a fine lumen, and is supported by the mesentery, which forms the division between the two halves of the collar-cavity. I am not at present certain as to the existence or non-existence of Bateson's "proboscis-gland" in this region of the body.

The lophophoral arms are deeply grooved on their ventral surfaces, and these grooves are continuous with shallower furrows (*gr.*), which pass along the ventro-lateral portions of the collar, on either side of the proboscis-stalk, as far as the region of the mouth. If, as can hardly be doubted, the tentacles are ciliated, it may be assumed that a current of water passes in the living animal down these grooves into the mouth, into which the current is directed by means of the opercular flap developed from the posterior border of the collar. It is probable that the gill-slits are, in this case, of great importance to the animal. The two lateral currents which have just been supposed to enter the mouth would doubtless introduce large quantities of water into the pharynx. The water would

pass to the gill-slits by a very slight alteration of the direction of these currents, since the gill-slits open ventro-laterally from the first division of the alimentary canal. Solid particles conveyed by the current could presumably be readily retained in the alimentary canal, whilst the water itself would naturally pour out by the gill-slits, which would be protected from the afferent current due to the tentacles by means of the operculum. It thus seems possible to conceive of a method in which the gill-slits may be of the greatest importance in connection with the straining of the water from the food-particles. Bateson has been led to assume that gill-slits are structures which have been developed within the Chordata, and it is suggestive that in *Cephalodiscus*, owing to the rich development of the tentacles, we appear to have a cause capable of inducing the evolution of perfora-

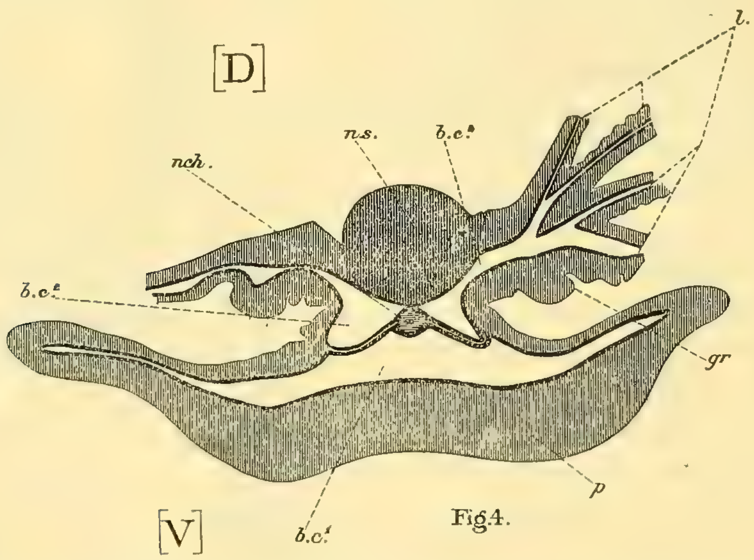

FIG. 4.—Transverse section through the collar and proboscis of an adult *Cephalodiscus*, passing in front of the mouth; *n.s.*, nervous system; *p.*, proboscis; *l.*, two of the lophophoral arms cut horizontally; *gr.*, grooves continuous with the grooves of the anterior lophophoral arms; *b.c.*[1], body-cavity of proboscis; *b.c.*[2], body-cavity of collar; *nch.*, notochord; D., dorsal, and V., ventral surface.

tions leading from the alimentary canal to the exterior. It may be perhaps profitable to consider whether gill-slits may not possibly have originated in this manner, and whether the arrangement found in *Balanoglossus* and other types may not have been developed from a *Cephalodiscus*-like condition by the metameric repetition of the slits, accompanied by a change in their function.

The preceding remarks relating to the supposed affinity of *Cephalodiscus* to *Balanoglossus* may with advantage be summed up by a statement of the various features which are common to the two genera.

1. Division of the body into proboscis, collar and trunk, this division being specially obvious, in *Cephalodiscus*, in the young bud.

2. Existence of an unpaired body-cavity in the proboscis, and of paired cavities in the collar and in the trunk.
3. Proboscis-pores (paired in *Balanoglossus kupfferi*), opening into the body-cavity of the præ-oral lobe.
4. Collar-pores in similar relation to the collar-cavity, their external apertures being overhung by an operculum developed from the collar.
5. Gill-slits (one pair for a considerable period in the embryonic history of *Balanoglossus*); their relation (in *Balanoglossus*, the relation of the first pair) to the operculum and to the external apertures of the collar-pores.
6. Existence of a notochord as a diverticulum of the alimentary canal, growing forwards into the proboscis-stalk.
7. Dorsal central nervous system, most richly developed in the collar, but extending on to the proboscis; the fact that the nervous tissue lies in the epidermis.

Before leaving this subject, it will be well to refer briefly to the highly interesting pelagic larva of *Balanoglossus*, discovered by Weldon in the Bahamas.[1] A noteworthy feature of this larva is the development of a series of tentacles arranged in six grooves passing, equidistant from one another, in a longitudinal direction along the surface of the præ-oral lobe. Although the tentacles are not in the same position as those of *Cephalodiscus*, it is a suggestive fact that this larva affords another case of the development of tentacles in the anterior part of the body in *Balanoglossus* or its allies, and it is at least possible that their appearance in the Tornaria may be due to a process of reversion or atavism.

It appears to me that whatever may be thought of any single similarity between the two genera given in the above list, the cumulative evidence of the whole sequence of resemblances points irresistibly to the conclusion that *Cephalodiscus* and *Balanoglossus* are near allies, and I would propose to remove *Cephalodiscus* from its previous position amongst the Polyzoa, and to place it definitely as a second genus in Bateson's group of the Hemichordata. The character of the Vertebrate features of *Cephalodiscus* (notochord, gill-slits, nervous system) appears to justify an approximation of this genus to *Balanoglossus* in particular rather than to any other group of the Chordata.

The most important difference between *Cephalodiscus* and *Balanoglossus* appears to me to consist in the relations of the dorsal and ventral surfaces in the two genera. The difference is, however, a non-essential one. Whilst in *Balanoglossus* the elongation of the embryo takes place in the line of its long axis, the ventral elongation of a similar embryo in a line at right angles to its primitive long axis would give rise to the condition found in *Cephalodiscus*. We may suppose that the stalk has originated in this

[1] *Vide Proc. Roy. Soc.*, vol. xlii. p. 146, 1887.

manner, and that the alimentary canal has acquired its adult relations by its partial passage into the ventral protuberance of the body.

Whilst it appears to me easy to compare *Cephalodiscus* and *Balanoglossus*, it does not seem to me impossible that the former may have affinities in other directions as well. For, imagine that the ventral elongation of the body would be conveniently postponed until after the end of a free larval life; the stalk might then be invaginated into the body of the larva in preparation for its evagination when metamorphosis should take place, as actually occurs in Actinotrocha. After the metamorphosis of the latter, the alimentary canal has the same dorsal flexure as in *Cephalodiscus*, and this explanation of the metamorphosis of *Phoronis* is in accordance with the suggestions of previous observers.

The following considerations may perhaps indicate some affinity between *Cephalodiscus* and *Phoronis*[1]:—

1. The archenteron of *Phoronis* is developed by a well-marked invagination, whilst part of the mesoblast (*vide* Caldwell) is formed by a process of (modified) archenteric pouching (as in *Balanoglossus*).

2. The præ-oral lobe is large in Actinotrocha, and is provided with a body-cavity which is completely shut off, by means of a septum, from the body-cavity of the trunk. The post-oral region is prolonged into tentacles, which, although differing in a striking manner from the tentacles of *Cephalodiscus*, may still have some connection with these structures, or with the operculum of the same genus.

3. The "foot" of *Phoronis* has precisely the same relations as the stalk of *Cephalodiscus.*

4. The nervous system of *Phoronis* occurs outside the basement-membrane. The ganglion of the præ-oral lobe of Actinotrocha is comparable with a portion of the nervous system of the Hemichordata, whilst the post-oral nerve-ring of *Actinotrocha* (following the line of the bases of the tentacles) may not impossibly be the homologue of the nerve-ring which passes round the posterior border of the collar in *Balanoglossus.* If this were the case, the lophophores of Actinotrocha and of *Phoronis* might be regarded as developments of the collar-region.

5. *Phoronis* possesses a complete ventral mesentery, the dorsal mesentery, however (persistent in *Cephalodiscus*), having disappeared in the adult animal. The ovaries and oviducts of *Cephalodiscus* are supported by lateral mesenteries which are apparently arranged in the same manner as the lateral mesenteries in Caldwell's diagram "*B.*"[2] The oviducts of *Cephalodiscus* do not, however, open into the body-cavity, and it is possible that the collar-pores, rather than the oviducts, may be the homologues of the nephridia of *Phoronis.*

[1] *Cf.* W. H. Caldwell, Prelim. Note on the Structure, Development, and Affinities of Phoronis, *Proc. Roy. Soc.*, No. 222, 1882; and Blastopore, Mesoderm, and Metameric Segmentation, *Quart. Journ Micr. Sci.*, vol. xxv., 1885.

[2] *Proc. Roy. Soc.*, 1882.

6. Previous observers (M'Intosh, Lankester, &c.) have been led to assume the affinity of *Phoronis* to *Cephalodiscus* and *Rhabdopleura*, this conclusion being based on such features as the relations of the adult lophophore to the mouth and anus.

It must be noted, on the contrary, that *Phoronis* is not known to possess any representatives of the notochord, gill-slits, collar-pores, and proboscis-pores of *Cephalodiscus*, whilst there is no evidence of the existence of a collar body-cavity in the former. It appears to me that a renewed consideration of *Phoronis*, anatomically and developmentally, can alone settle the question of the possibility of an affinity between it and *Cephalodiscus*.

The remarkable larva of *Balanoglossus* described by Weldon (*loc. cit.*, fig. 3) is in some of its features by no means unlike Actinotrocha. Such features are the general form of the præ-oral lobe and trunk, the absence of the notochord and gill-slits, and the existence of only three divisions of the body-cavity. These are (1) the unpaired cavity of the præ-oral lobe, and (2) the two cavities of the trunk-region. In the absence of these cavities and of the notochord and gill-slits Actinotrocha differs from the larval *Balanoglossus* described by Bateson. It cannot, however, be denied that the difference between the tentacles of Weldon's larva and those of Actinotrocha is very considerable, if not fundamental.

The relation between *Cephalodiscus* and *Rhabdopleura* is in need of further elucidation. In spite of the great resemblance between the lophophores and epistomes of the two genera, many of the most important structures found in *Cephalodiscus* are not known to exist in *Rhabdopleura*, and there does not at present appear sufficient justification for the removal of *Rhabdopleura* to the Hemichordata, although the balance of evidence might perhaps be in favour of so doing.

I do not think that the above considerations are in any way calculated to strengthen the view that *Phoronis* and the Polyzoa are nearly related. The result of the examination of *Cephalodiscus* appears to me to show that this genus (and *Rhabdopleura* also ?) must be entirely removed from the Polyzoa. If this is the case, it is obvious that any affinity which may be shown to exist between *Cephalodiscus* and *Phoronis* can in no way affect the question of the relationship of the latter to the Polyzoa.

CONTENTS.

PLATE I.

PLATE I.

Cœnœcium of *Cephalodiscus dodecalophus*, about the natural size; a few of the branches terminate in somewhat flattened tips. At *a*, one of the pillars, which like aerial roots pass downwards to the stones and sponges on which it grows, is represented, its tip being expanded into a broad surface. Numerous inosculations take place between the various branches.

W. C. M. & E. Prince del.

F. Huth Lith. Edin.

CŒNŒCIUM OF CEPHALODISCUS DODECALOPHUS, Mc I.
(uncoloured)

PLATE II.

PLATE II.

Polypide of *Cephalodiscus dodecalophus*, seen from the ventral surface, and enlarged under a lens, the actual length of the entire animal being about 2 mm. Only a few of the tentacular plumes are visible, the rest being concealed by the dense mass of filaments. The tip of the pedicle bears an early bud, the pedicle of which is somewhat elongated. This example presented numerous minute pigment-spots of a brownish hue all over its surface.

W. C. M. del.

DODECALOPHUS, M'I.

PLATE III.

PLATE III.

Fig. 1. Polypide of *Cephalodiscus dodecalophus*, obliquely seen from the ventral surface; much enlarged, and having the buccal shield removed. The pedicle is in a state of extension, with a fairly advanced bud at the tip; *an*, anus; *pl.*, post-oral lamella; *m*, mouth.

Fig. 2. Lateral view of a polypide, also deprived of the buccal shield, and much enlarged. The pedicle is contracted and bent forward, with a pair of buds at the tip. The same letters are used as in fig. 1; *ov*, the position of the large ovum, which distends the lateral region just behind the pigment-spots (*od*); *bp*, torn tissues at the base of the plumes, which have been removed.

Fig. 3. Lateral view of an entire specimen, with the pedicle as well as the buccal disk thrust outwards, or ventrally. The buccal shield has fallen from the larger of the two buds at the tip of the pedicle. The alimentary canal has been somewhat diagrammatically outlined in this example; *œ*, above the line is the pharynx, below is the œsophagus; *vt*, stomach, largely distended; *vtd*, peculiar region following the stomach, and presenting a thick glandular coat with a distinct fold beyond the point touched by the dotted line, and which probably is homologous with the second stomachal dilatation in *Phoronis*; *r*, rectum, usually much dilated; *bs*, buccal shield; *pl.*, post-oral lamella.

Fig. 4. An abnormal specimen, similarly magnified and viewed laterally. The pedicle is absent, a prominence only (*ped*) indicating its position. Instead of the smoothly bulbous posterior extremity (almost like the bowl of a retort), a somewhat sharp angle occurs ventrally. The anus is elevated on a rectal cone.

CEPHALODISCUS DODECALOPHUS, M'I.

PLATE IV.

PLATE IV.

Fig. 1. Tentacular plume of *Cephalodiscus*, seen as a semitranslucent object. The line in the middle of the filaments indicates the axis or skeleton; × 90.

Fig. 2. Portions of the pinnæ or filaments acted on by dilute potash so as to exhibit the central axis or skeleton, which at *a* has been exposed. The cellulo-granular coating of the organs is hypodermic; × 350.

Fig. 3. Slightly oblique section of the bulbous tip of one of the plumes, showing the large globules and gland-cells. The hypoderm has intruded on the left, showing that the slice has been made close to the base of the process; × 470.

Fig. 4. Transverse section of the tip of a plume just behind the foregoing, and while the central lumen remains very distinct. The hypoderm shows somewhat regular wedge-shaped divisions, as if composed of a single layer of large cells. The wall of the central cavity presents numerous fibres projecting all round, as if the reticulations were already commencing; × 470.

Fig. 5. Transverse section of the pedicle, showing the remarkable form usually assumed by the elastic basement-tissue (*bt*) in contraction. The hypoderm (*hp*) occurs externally; and within the basement-tissue the large muscular fibres and somewhat gelatinous connective-tissue fill up the central region. The small dorsal and the large ventral incurvations are readily recognised, as well as the two lateral ventral projections of the basement-tissue. The hypoderm on the ventral surface has been somewhat stretched; × 350.

W. C. M. del. Fig. 5, E. Prince

F. Huth, Lith^{r} Edin^{r}

CEPHALODISCUS DODECALOPHUS, M^{c} I.

PLATE V.

PLATE V.

Fig. 1. Tip of one of the plumes of the polypide of *Cephalodiscus*, showing the glandular nature of the enlarged region. The filaments (*f*) have been turned to the left; *ca*, central axis of main stem; *hp*, hypoderm. The longitudinal fibres running along the axis are observed to the left as well as over the axis; × 210.

Fig. 2. Portion of the middle of a plume with the bases of the filaments (*f*), viewed laterally, after the action of a dilute solution of potash. The skeletal axis is observed in the centre of each filament, and as this skeletal axis (*sk*) widens out at its base, the double outline at each side is well marked; *ca*, central axis of main stem, with its longitudinal fibres; × 350.

Fig. 3. Transverse section of a young bud on the appearance of the first two lophophoral processes or plumes (*lp*) as two rounded bosses composed of tissue resembling hypoderm. The buccal disk (*bd*) is cut at its anterior region, but the central space (*bc*) of the organ is well developed. The collar space (*vc*) is comparatively large at this stage, and lies close beneath the nerve-centre; × 350.

Fig. 4. Transverse section of the terminal region of the body-cavity of an older bud than the foregoing, the tip of the alimentary canal (*al*) being left as a thin plate in the centre, and bound dorsally and ventrally by the median mesentery (*ms*). The great longitudinal muscle is cut near the commencement of the pedicle, and already shows the double ventral curvatures so characteristic of the latter; *bt*, basement-tissue; *co*, the body-cavity; × 350.

Fig. 5. Ovum on its escape from the adult; *ec*, egg-capsule; *ov*, ovum proper; *st*, stalk; × 90.

Fig. 6. Outline of another ovum in which the yolk is ovoid, instead of circular as in the former case; × 90.

Figs 1,2,5,6, W.C.M. Figs 3,4 E. Prince del.

PLATE VI.

PLATE VI.

Fig. 1. Longitudinal section of the tip of the pedicle of an adult *Cephalodiscus*, showing the attachment of a young bud just above the terminal surface (which is somewhat sucker-like); *lm*, strands of longitudinal muscles; *hps*, modified hypoderm forming the terminal surface of the pedicle; *gm*, section of a young bud, showing the central chamber (*ch*) continuous with the axis of the pedicle of the adult; × 350.

Fig. 2. Transverse section of an adult *Cephalodiscus* through the region of the mouth (*m*) and ovaries, one pigment-mass (*od*), however, only having been cut. The buccal shield (*bs*) on the right is seen folding over dorsally (*bsp*), so as to run into the tissues at the bases of the plumes (*br*); *g*, grooves at the bases of the lophophoral arms. The notochordal region lies between this letter and *m*, though the notochord is not seen in this section. The mouth is observed at (*m*) and the pharyngeal region with its numerous folds and a gill slit (*gs*), while on the left is a section of the post-oral lamella (*pl*) with its central cavity or chamber; *r*, greatly distended rectum; *od*, pigment of oviduct; *ov*, large, and *ov'*, small ova, with nuclei and nucleoli; × 90.

Fig. 3. Transverse section of the shield and dorsal region in the long axis of the central region of the nervous system (*nc*). The thick coating of hypoderm (*hp*) bounds the latter externally, while internally it rests on the basement-tissue (*bt.*); *bp*, sections apparently of the shield-pores in their progress inwards; *bsm*, radial muscles of the buccal disk or shield; *hs*, hypoderm of shield; *od*, position of the pigment of the oviducts; × 210.

Fig. 4. Transverse section of the same bud as in Pl. V. fig. 4, in the anterior region, so as to strike the commencement of the nerve-centre (*nc*), with the central cavity (*c*). The young plumes are irregularly cut from their variable position, and the sides of the disk fold over into the basal region of the plumes. The large size of the terminal process of the plumes is well seen in the larger organ; × 210.

Fig. 5. Section a little behind the foregoing, giving the nerve-centre (*nc*) in full development, under the thick hypodermic coat (*hp*), while the tip of the anus (*an*) has also been included; *cva*, collar space going to plumes; *bsm*, radial muscles of buccal disk; *c*, region of the notochordal. The plumes are more widely separated in this region, and the young filaments have the form of hypodermic papillæ; × 210.

Fig. 6. A somewhat oblique section through the buccal shield (*bs*) and the post-oral lamella (*pl*) with its central cavity, to which the dotted line goes. Beneath is a collar pore (*cp*), which is, however, indifferently shown in this section. The nerve-centre (*nc*) and a pore (*bp*) leading into the cavity of the shield are also cut, the two body-cavities of the region lying above the former (*nc*) in this view, that is ventrally in nature. The other parts are an ovary (*ov*) and a portion of the pigment-mass of an oviduct (*od*); × 90.

W. C. M. & E. Prince del.

CEPHALODISCUS DODECALOPHUS, M^{c}I.

PLATE VII.

PLATE VII.

Fig. 1. Portion of the cœnœcium of *Cephalodiscus*, about natural size, tinted as in the spirit-preparations.

Fig. 2. Transverse section of a pedicle of an unstained specimen, showing a somewhat different arrangement of the folds of the basement-tissue and the central muscular fibres; letters as before; × 350.

Fig. 3. Oblique section of the chief area of the nerve-tissue (*nc*), which lies under the thick hypoderm (*hp*) between the plumes (*br*). The collar spaces (*cv*) lie next the basement-tissue, bounding the nerve-centre internally, and a trace apparently of the notochord is observed at *c*. Some of the folds (*mf*) of the mouth have been included in the section, and the radiate muscles (*bsm*) of the buccal shield are observed on the left; × 350.

Fig. 4. Transverse section of the same bud as in Pl. VI. fig. 5, somewhat behind the former. The body-cavity (*co*) now shows the rudimentary generative organs (*ov*), the rectum (*r*), and the œsophagus (*œ*) in section. The collar spaces (*cv*) are distinct, and the post-oral lamella (*pl*) is seen on the right. The position of the buccal shield is indicated by the letters *bs*; × 210.

Fig. 5. Transverse section of the same bud posterior to the former, and the three regions of the alimentary canal now occupy the body-cavity, viz., *r*, the intestine; *vt*, the stomach, while what is probably the pharynx (*œ*) lies ventrally. A collar pore is observed at *cp*; *pl*, post-oral lamella; other letters as before.

W. G. M. & E. Prince del.

F. Huth, Lith^r Edin^r

CEPHALODISCUS DODECALOPHUS, McI.

THE

VOYAGE OF H.M.S. CHALLENGER.

ZOOLOGY.

REPORT on the POLYZOA collected by H.M.S. Challenger during the years 1873–76. By GEORGE BUSK, F.R.S., V.P.L.S., &c.

PART II.—The CYCLOSTOMATA, CTENOSTOMATA, and PEDICELLINEA.

INTRODUCTION.

So much has been written of late years concerning the Polyzoa, that it is not possible for me here to name all those to whom I have been indebted for assistance in the preparation of this Report, but among the most important recent contributions to our knowledge of all the three orders now under consideration, must be mentioned the valuable works of Mr. Hincks[1] and Professor Smitt.[2] To M. L. Joliet[3] we owe papers, both anatomical and descriptive, on the Polyzoa of the French Coast. Mr. P. H. Macgillivray,[4] has described and figured many new species of CYCLOSTOMATA belonging to the Australian region. Mr. Waters[5] has given descriptions of recent species from the Bay of Naples, as well as of fossil Australian species; and Dr. J. Jullien[6] of species collected in the

[1] Hincks, Brit. Mar. Polyz., 1880, and various papers in *Ann. and Mag. Nat. Hist.*, &c.

[2] Smitt, Hafs-Bryoz. Uteckl. och Fettkr., 1864; Bryoz. Mar., 1867; Kritisk Förteckn., 1865, 1871; Florid Bryoz., pt. i., 1872.

[3] Joliet, Les Bryozoaires des Côtes de France, *Archives d. Zool. Expér.*, t. vi., p. 193, 1877.

[4] Macgillivray, P. H., *Nat. Hist. Vict.*, decades iv. and vii.; *Proc. Roy. Soc. Vict.*, Polyzoa, parts iv. vi., vii., viii., ix.

[5] Waters, *Ann. and Mag. Nat. Hist.*, ser. 5, vol. iii.; *Quart. Journ. Geol. Soc.*, vol. xl. p. 674, 1884.

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[5] Waters, *Ann. and Mag. Nat. Hist.*, ser. 5, vol. iii.; *Quart. Journ. Geol. Soc.*, vol. xl. p. 674, 1884.

[6] Jullien, *Bull. Soc. Zool. de France*, t. vii., 1882.

Atlantic by the "Travailleur." With regard to the PEDICELLINEA I must express my obligations to Drs. Nitsche,[1] Hatschek,[2] Salensky,[3] &c., for the information derived from their researches.

The total number of species enumerated in this part of my Report is forty-six, of which number thirteen still appear to me to be new, and three or four others have only been described and named since the Challenger collection was made; if I have overlooked the descriptions of any others I can only express my regret that it should be so, as I have made every endeavour to keep pace with the recent additions to our knowledge on the subject.

Of the number of species above mentioned by far the greater part, viz., thirty-three, belong to the sub-order CYCLOSTOMATA, of which, however, only five are new. Of the CTENOSTOMATA there are only eleven species in all, but of these seven are new, though none of them present any new generic type; this very much larger proportion of new species can be accounted for probably by the fact that this sub-order has been much less fully studied hitherto than either the CHEILOSTOMATA or CYCLOSTOMATA. Belonging to the PEDICELLINEA, only two species have come under my notice, of which but one is now described for the first time, the other having been named by Mr. Hincks in 1884.

CLASSIFICATION.

1. The arrangement of the sub-order CYCLOSTOMATA followed in this Report, as exemplified in the accompanying Table (see p. viii.), is nearly the same as that adopted in my Monograph of the Crag Polyzoa, 1857, and in the British Museum Catalogue, pt. iii., 1875; the number of species procured by H.M.S. Challenger belonging to this sub-order not having been sufficiently large to lead to any material change in it.

2. In the sub-order CTENOSTOMATA, again, the number of species in the collection was too small to justify the attempt at forming any different general scheme, and therefore I have followed, as nearly as may be, the arrangement adopted by Mr. Hincks in his British Marine Polyzoa, only differing from him in the definition of the two principal divisions.

3. With respect to the order PEDICELLINEA all that I need say is, that though the total number of species collected on the voyage only amounted to two, they have appeared to me to deserve recognition as a new generic type, to which I have given the name of *Ascopodaria*, but it does not seem necessary for me to enter into any disquisition as to a scheme of classification beyond what has been already written by Mr. Hincks, Dr. Nitsche, Professor Smitt and others.

[1] Nitsche, *Zeitschr. f. wiss. Zool.*, Bd. xx. p. 343, 1870.
[2] Hatschek, *Zeitschr. f. wiss. Zool.*, Bd. xxix. p. 502, 1877.
[3] Salensky, *Ann. d. Sci. Nat.*, sér. 6, t. v. p. 27, 1877.

Distribution.

1. *Geographical.*

I have thought it convenient for the sake of uniformity, and to facilitate reference, to arrange the species enumerated in this second part of the Report into the following seven divisions of the ocean, in the same manner that the Cheilostomata were divided in the first part.

A. North Atlantic Region, between the parallels of 70° W. and 20° E.
B. South Atlantic Region, from 70° W. to 20° E.
C. South Indian or Kerguelen Region, from 20° E. to 110° E.
D. Australian Region, from 110° E. to 160° W. and S.
E. Philippine or Japanese Region, from 110° E. to 160° W. and N.
F. North Pacific Region, from 160° W. to the coast of North America.
G. South Pacific Region, from 160° W. to 70° W.; but from this region no species belonging to any of the orders referred to in this part of the Report were procured.

In the following List, to the names of the species procured at each Station a reference is added, by corresponding letters, to the other regions in which it was found, so that its geographical distribution may be seen at a glance.

2. *Bathymetrical.*

The Stations in each geographical region, in the List, are arranged in bathymetrical order, beginning with those of the greatest depth; it will be seen that only two species of Cyclostomata occur at depths greater than 1000 fathoms, viz., one at 1600 and one at 1450, the former, however, also being found at various depths, from 50 fathoms downwards; four or five others were found at 450 to 600 fathoms, but by far the larger number were procured at between 50 and 150 fathoms, and ten in shallow water. Of the Ctenostomata only three occurred at depths as great as 150 fathoms, the remaining eight having all come from depths less than 40 fathoms. The only two species belonging to the Pedicellinea group both came from 150 fathoms.

3. *Geological.*

To the sub-order Cyclostomata belong most of the oldest fossil Polyzoa that have been found up to this time, whilst "as yet we have no clear evidence that Cheilo-

stomatous types existed in Palæozoic times;"[1] although in the Mesozoic and Tertiary strata fossil CHEILOSTOMATA are numerous. The palæontological evidence as to the antiquity of the CYCLOSTOMATA is fully confirmed and strengthened by the embryological researches that have recently been so carefully and accurately made by various authors; for instance M. Barrois[2] says that the study of the structure of the larva and of the formation of the cell coincides with palæontology in furnishing us with perfectly concordant results, which are conclusive as to the antiquity of the CYCLOSTOMATA. Many of the species even have a wide distribution in time, for out of the thirty-three included in this collection, fourteen have already been identified in the fossil state.

No fossil forms belonging either to the CTENOSTOMATA or to the Entoproctan Polyzoa have hitherto been identified, but Mr. Vine has thrown out a hint, in a paper on *Ascodictyon*,[3] that perhaps *Ascodictyon filiforme* may be a primitive representative of the stoloniferous Vesiculariadæ, or possibly of the Entoprocta. That this latter order is of great antiquity is also confirmed by its embryonic history, for the same eminent authority, above quoted, M. Barrois,[4] after the most careful and elaborate comparison of the larvæ of the various Ectoproctan and Entoproctan groups, comes to the conclusion that "the larvæ of Entoprocta represent the primitive type from which all the others are derived."

A.—NORTH ATLANTIC REGION.

STATION 75, lat. 38° 38′ N., long. 28° 28′ 30″ W.; 450 fathoms; volcanic mud.

Idmonea milneana, C. | *Idmonea irregularis*.

CAPE VERDE ISLANDS, 100 to 120 fathoms.

Hornera frondiculata.

STATION 36, lat. 32° 7′ 25″ N., long. 65° 4′ W., off Bermuda; 30 fathoms; coral.

Crisia denticulata, var. *patagonica*. | *Amathia lendigera*.

CAPE VERDE ISLANDS, 10 fathoms.

Crisia conferta, D.

STATION 109, 0° 55′ 38″ N., long. 29° 22′ 35″ W., off St. Paul's Rocks; shallow water.

Crisia denticulata, B, D.

[1] Vine, *Quart. Journ. Geol. Soc.*, vol. xl. p. 332, 1884.
[2] Barrois, *Ann. and Mag. Nat. Hist.*, ser. 5, vol. x. p. 391 (footnote).
[3] Vine, *Ann. and Mag. Nat. Hist.*, ser. 5, vol. xiv. p. 87.
[4] Barrois, *loc. cit.*, p. 401.

B.—SOUTH ATLANTIC REGION.

STATION 320, lat. 37° 17′ S., long 53° 52′ W.; 600 fathoms; green sand.

Crisia acuminata.	*Idmonea fissurata.*
Idmonea marionensis, C.	*Hornera lichenoides.*

STATION 135, lat. 37° 1′ 50″ S.; long. 12° 19′ 10″ W., off Tristan da Cunha Islands; 60 to 360 fathoms.

Crisia biciliata.	*Alecto granulata.*
Crisia denticulata, A, D.	*Diastopora patina.*
Crisia acuminata.	*Lichenopora fimbriata.*
Crisia cylindrica.	*Lichenopora hispida.*
Idmonea atlantica.	*Fasciculipora ramosa.*

Ascopodaria discreta.

STATION 142, lat. 35° 4′ S., long. 18° 37′ E.; 150 fathoms; green sand.

Alcyonidium flustroides.

OFF BAHIA, 10 to 40 fathoms.

Amathia distans.	*Amathia brasiliensis.*

Farrella atlantica.

SIMON'S BAY, Cape of Good Hope; 18 fathoms.

Idmonea atlantica.

STATION 315, lat. 51° 40′ S., long. 57° 50′ W.; 12 fathoms; sand and gravel.

Tubulipora flabellaris.	*Tubulipora fimbria.*

C.—SOUTH INDIAN OR KERGUELEN REGION.

STATION 147, lat. 46° 16′ S., long. 48° 27′ E.; 1600 fathoms; Diatom ooze.

Idmonea marionensis, B.

PRINCE EDWARD ISLAND, 80 to 150 fathoms.

Crisia holdsworthii.	*Idmonea milneana*, A.
Idmonea marionensis, B.	*Pustulopora proboscidea.*

STATION 149, off Kerguelen Islands; 28 to 105 fathoms.

Crisia eburnea, var. laxa.	*Idmonea atlantica.*

STATION 151, off Heard Island; 75 fathoms; volcanic mud.

Idmonea marionensis, B.
Hornera violacea.
Pustulopora proboscidea.
Pustulopora deflexa.
Supercytis tubigera.

STATION 144A, lat. 46° 48′ S., long. 37° 49′ 30″ E., Marion Islands; 69 fathoms; volcanic mud.

Crisia holdsworthii.
Idmonea marionensis, B.
Idmonea australis, D.
Pustulopora proboscidioides.

D.—AUSTRALIAN REGION.

STATION 176, lat. 18° 30′ S., long. 173° 52′ E.; 1450 fathoms; Globigerina ooze.

Crisia elongata.

STATION 163A, lat. 36° 59′ S., long. 150° 20′ E., off Twofold Bay; 150 fathoms; green mud.

Crisia conferta, A.
Amathia spiralis.
Amathia tortuosa.
Ascopodaria fruticosa.

STATION 167, lat. 39° 32′ S., long. 171° 48′ E.; 150 fathoms; blue mud.

Supercytis digitata.

STATION 162, lat. 39° 10′ 30″ S., long. 146° 37′ E., Bass Strait; 38 fathoms; sand and shells.

Pustulopora regularis.
Amathia spiralis.

STATION 163B, lat. 33° 51′ 15″ S., long. 151 22° 15″ E., off Port Jackson; 35 fathoms; hard ground.

Idmonea australis, C.
Hornera foliacea.

STATION 161, lat. 38° 22′ 30″ S., long. 144° 36′ 30″ E., off Port Philip; 33 fathoms; sand.

Crisia acropora.
Hornera foliacea.
Amathia spiralis.

STATION 188, lat. 9° 59′ S., long. 139° 42′ E.; 28 fathoms; green mud.

Amathia semispiralis.
Vesicularia papuensis.
Cylindræcium papuense.

Station 172, lat. 20° 58′ S., long. 175° 9′ W., off Nukalofa, Tongatabu; 18 fathoms; coral mud.

Idmonea radians, F.

Station 186, lat. 10° 30′ S., long. 142° 18′ E., off Cape York; 8 fathoms; coral mud.

Crisia denticulata, A, B. | *Idmonea eboracensis*.
Amathia connexa.

E.—PHILIPPINE OR JAPANESE REGION.

Off Zebu, Philippine Islands.

Crisia denticulata, var. *gracilis*.

F.—NORTH PACIFIC REGION.

Off Honolulu, Sandwich Islands; 20 to 40 fathoms.

Idmonea radians, D.

G.—SOUTH PACIFIC REGION.

None.

Measurements.

The metrical system is now so generally in use for scientific purposes that I have adopted it for all the measurements of the magnified figures, and they are accordingly given in millimetres or tenths of a millimetre. The figures are nearly all enlarged by 25 or 50 diameters, and scales are appended to all the plates.

Table of Classification.

DESCRIPTION OF GENERA AND SPECIES.

Sub-Order II. CYCLOSTOMATA, Busk.

Cyclostomata, Bk., Smitt, Hincks, Auctt.
Tubuliporina, M.-Edwards, Johnst., &c.
Auloporina and *Myrioporina* (pars), Ehrenberg.
Cerioporina (pars), Bronn.
Centrifuginea (pars), d'Orbigny.
Millêporés à cellules (pars), Blainville.

Character.—Zoœcia tubular, calcareous, partially free or wholly connate or immersed; aperture terminal, inoperculate.

Division I.—ARTICULATA seu RADICATA.

Radicellata, d'Orbigny, Hincks, Smitt, &c.
Articulatæ s. Radicatæ, Bk., Crag Polyz.

Character.—Zoarium branched, divided into distinct internodes by flexible chitinous joints; affixed by chitinous, or calcareous jointed stoloniform radical tubes. Zoœcia disposed in single or double longitudinal series, all facing in one direction.

Family I. Crisiadæ.

Les Crisies, M.-Edwards.
Crisiadæ, Johnst., Busk, &c.
Crisiidæ, Busk, Hincks, &c.
Crisieæ, Smitt.
Crisidea, Reuss.
Crisidæ, d'Orbigny.

Character.—The only family.

The Family here contains:—

1. *Crisia.*

(1) *Crisia biciliata*, Macgilliv. (Pl. I. figs. 1, 2).
(2) *Crisia eburnea*, var. *laxa* (Pl. II. fig. 1).
(3) *Crisia denticulata*, Lamk. (Pl. II. fig. 3).
Crisia denticulata, var. *a*, *gracilis* (Pl. I. fig. 4).
Crisia denticulata, var. *β*, *patagonica*.
(4) *Crisia elongata*, M.-Edw. (Pl. I. fig. 3).
(5) *Crisia acuminata*, n. sp. (Pl. III. fig. 1).
(6) *Crisia acropora*, Bk.
(7) *Crisia holdsworthii*, Bk. (Pl. III. fig. 2).
(8) *Crisia conferta*, Bk. (Pl. II. fig. 5).
(9) *Crisia cylindrica*, n. sp. (Pl. II. figs. 2, 4).

1. *Crisia.*

Sertularia (pars), Linné.
Cellularia (pars), Pallas.
Cellaria (pars), Solander, Lamk.
Tibiana (pars), Lamk., Schweigger, Blainville, Lister.
Falcaria (pars), Oken, Gray.
Eucratea (pars), Esper, Lamx., Fleming, &c.
Crisia (pars), Lamx., Johnst., Gray, Auctt.
Crisidia (pars), M.-Edwards, Busk, d'Orbigny (1852).
Filicrisia, d'Orbigny (1851).

Character.—Zoœcia disposed in a single or double longitudinal series. Oœcia modified zoœcia, with a tubular aperture, walls punctate.

§ *a.* Uniserial.

Crisidia, M.-Edwards, Busk, Auctt.
Unicellaria (pars), Blainville.
Falcaria, Oken, Gray.
Tibiana, Lister (*nec* Blainville, Lamx.).
Unicrisia, d'Orb., Vine.

No species belonging to this section occurs in the Challenger collection.

§ *β.* Zoœcia disposed in a double series, opposite or alternate.

§§ *α.* Zoœcia opposite in pairs, from two to four (rarely six) in an internode.

Bicrisia, d'Orbigny.
Crisia (pars), Auctt.

(1) *Crisia biciliata*, Macgilliv. (Pl. I. figs. 1, 2).

Crisia biciliata, Macgilliv., Nat. Hist. Vict., Dec. iv. p. 37, pl. xxxix. fig. 2.

Character.—An opposite pair of perfect zoœcia in each internode, with a third intermediate aborted one between them, from which the succeeding pair or a branch arises. A pair of long, jointed spines articulated to the outer part of each zoœcium, excepting those bearing the secondary branches. Oœcia small, much elongated, pyriform, situated at the angle of a bifurcation. Zoœcia 0·07 mm. in diameter.

Habitat.—Station 135, Tristan da Cunha, 60 to 1100 fathoms, rock and shells; [Williamstown, Mapleston; Warrnambool, Watts].

As Mr. Macgillivray remarks (p. 38) "The aspect and general arrangement of the cells are the same as in *C. edwardsiana*, d'Orb. There are two cells in each internode, except in those from which the branches originate. The cells, as he observes, are not so long as those represented in M. d'Orbigny's figure of *C. edwardsiana*, and are wider superiorly, and the free part is not so long, and is much more abruptly curved forwards; the oœcial cell is smaller, more elongated, and each lateral cell supports usually two, but sometimes only one long-jointed spine."

Mr. Macgillivray further remarks that he is doubtful to what species my description and figures of *Crisia edwardsiana* (Brit. Mus. Cat., pt. iii. p. 5, pl. ii. figs. 5–8) refer, and I am compelled to say that subsequent examination of the specimens from which that description was chiefly drawn, some of which were from Tierra de Fuego, collected by Mr. Darwin, and others from New Zealand, procured by Dr. Sinclair, has left considerable doubt in my mind as to the identity of these two forms; the latter, it is highly probable, is distinct from the Patagonian *Crisia edwardsiana*, in which the zoœcia, as represented by M. d'Orbigny, are very long and erect, whilst in the New Zealand species they are short and curved forwards. There is also another form or variety closely approaching the New Zealand species, but in some measure intermediate between that and the South American one, which may turn out to be distinct from either, and to form an intermediate variety, characterised by a tendency to have two or more pairs of cells in some of the internodes, and less exactly opposite. All three, however, are furnished with only a single articulated spine, which arises close below the mouth, instead of low down the back as in *Crisia biciliata*. One character is observable in the New Zealand form which I have not noticed in the others, viz., that the dorsal aspect of the pair of zoœcia is entire, and faintly striated transversely.

§§ *b*. Zoœcia numerous (more than six) in each internode, alternate on the two sides. Oœcia irregularly disposed, often absent.

Crisia (pars), Auctt.

(2) *Crisia eburnea*, var. *laxa* (Pl. II. fig. 1).

Sertularia eburnea, Linné.
La Sertolara d'avorio, Cavolini, Sprengel.
Cellularia eburnea, Pallas, Bruguières.
Cellaria eburnea, Soland., Bosc, Lamarck, Johnst., Transact. Newc. Soc., vol. ii. p. 262, pl. xi. fig. 5.
Crisia eburnea, Lamx., M.-Edwards, Fleming, Johnst., Templeton, Blainville, Risso, Couch, Hincks, Norman, Alder, Hassall, Van Beneden, Rech. s. l'Anat. des Bryoz., Mém. Brux., t. xviii. p. 52, pl. vi. figs. 12–16; Busk, d'Orbigny, Pal. Franç., p. 598; Joliet, Arch. de Zool. Expér. et Gén., vol. vi., 1877.

Character.—Zoarium small, tufted. Zoœcia usually three to seven in each internode (rarely nine to eleven) loosely aggregated. Branches usually arising from the first or lowest zoœcium in an internode, sometimes from the second or third. Aperture circular, sometimes slightly pointed on one side. Oœcia pyriform, surface even. Branches 0·15 mm., zoœcia about 0·07 mm. in diameter.

Habitat.—Station 149, D. and I., off Kerguelen Island, 28 to 105 fathoms, volcanic mud.

[Seas of Europe; Spitzbergen, Smitt; Madeira; Adriatic; Roscoff, Joliet.]

Except in its rather more loose mode of growth this form does not differ in any essential character from the common *Crisia eburnea.*

(3) *Crisia denticulata*, Lamarck, sp. (Pl. II. fig. 3).

Cellaria denticulata, Lamk.
Crisia luxata, Fleming, Blainville, Johnston (ed. 1), Couch.
Crisia denticulata, M.-Edw., Johnst., ed. 2, p. 284, pl. l. figs. 5–6; Gray, Sars, d'Orb., Gosse, Alder, Busk, Hincks, Norman, Smitt, Krit. För. Öfver. Skan. Hafs.-Bryoz., p. 117 (*nec* Floridan Bryoz.); Waters, Ann. and Mag. Nat. Hist., ser. 5, vol. iii. p. 269; Vine, Joliet.
Cellaria arctica, Sars (teste Smitt).

Character.—Zoarium 1 to 3 inches high, of straggling growth. Zoœcia almost straight, connate nearly throughout their entire length. Aperture elliptical, usually pointed on one side. Oœcial cells truncate, often with three or more transverse annulations. Branches usually arising in an internode from or above the fourth cell (sometimes from the second in the lower parts of the zoarium). Branches 0·23 mm., zoœcia 0·07 mm. wide.

Habitat.—Off St. Paul's Rocks, shallow water. Station 186, lat. 10° 30′ S., long. 142° 18′ E., 8 fathoms, coral mud. Off Inaccessible Island, Tristan da Cunha, 60 to 90 fathoms.

[Coasts of Britain and Ireland; Norway; Spitzbergen? Grand Manan? Stimps.; Bay of Naples; Roscoff.]

Var. *a. gracilis* (Pl. I. fig. 4).

Character.—Closely resembles *Crisia denticulata* but of far slenderer habit, rarely if ever presenting any longitudinal interspaces between the series of zoœcia; branches not more than 0·2 mm. wide; zoœcia about 0·06 in diameter.

Habitat.—Off Zebu, Philippine Islands.

Var. *β. patagonica*, d'Orbigny (?)

Crisia patagonica, d'Orb., Voy. dans l'Am. Mér. Polyp., p. 7, pl. i. figs. 1–3.

"Cells from nine to nineteen, straight, very distinct; branches arising from second or third cell; sometimes two from an internode, when the second arises from the sixth cell. Joints black." Diameter of branches about 0·23 mm., and of zoœcia 0·08 mm.

Habitat.—Station 36, off Bermudas, 30 fathoms, coral.

[Patagonia.]

(4) *Crisia elongata*, M.-Edw. (Pl. I. fig. 3).

Crisia elongata (?), M.-Edwards, Réch. sur les Crisies, p. 10, pl. vii. fig. 2; Busk, Brit. Mus. Cat., pt. iii. p. 3, pl. iv. figs. 5–6; Waters.

Character.—Zoarium composed of long straight branches. Zoœcia, twelve to twenty-one or more in each internode; often much produced and curved forwards. Aperture circular, even; branches arising from the fifth to the seventh zoœcium. Oœcial cells unknown. Surface finely granular. Branches 0·3 mm., zoœcia 0·07 mm. wide.

Habitat.—Station 176, lat. 18° 30′ S., long. 173° 52′ E., 1450 fathoms, Globigerina ooze.

[Red Sea or Mediterranean? M.-Edw.; Algoa Bay.]

Whether the specimen (the only one in the Challenger collection) here described and figured really be the form described by M. Milne-Edwards I am by no means now convinced, but it is the same as that to which I have given the same appellation in the British Museum Catalogue. One reason for the doubt is that M. Milne-Edwards describes his *Crisia elongata* as narrower than *Crisia denticulata*, while that I have to name is certainly quite as wide, if not wider, than the usual form of *Crisia denticulata*.

(5) *Crisia acuminata*, n. sp. (Pl. III. fig. 1).

Character.—Zoarium 1 to 2 inches high, composed of long, straggling, flexuose branches dividing once or twice dichotomously and terminating in two short bifurcations. One of the terminal zoœcia (usually the penultimate), is often produced into a long,

acute, tapering spine. The internodes comprise from seven to eleven zoœcia, usually seven or nine, and the branches always arise from the second. Zoœcia about half connate, produced above and curved abruptly forwards; aperture circular, even, border thin. Surface sparsely punctate; dorsal aspect finely striated, with a row of punctures down each interspace. Branches convex before and behind, and without any intermediate longitudinal space. Joints white or pale brown. Oœcial cells? Branches 0·2 to 0·25 mm., zoœcia 0·1 mm. wide.

Habitat.—Station 320, lat. 37° 17′ S., long. 53° 52′ W., 600 fathoms, green sand.

Somewhat like *Crisia denticulata*, but differing in the general habit which is characterised by the very long, straggling, wavy, or flexuose, sparingly forked branches, sterminating in two or three short forks. Many of the ultimate segments exhibit a longer or shorter, acutely tapering, pointed spine, formed of a metamorphosed zoœcium. A similar disposition may be occasionally seen in a species of *Crisia*, to which I have given the name of *Crisia sinclairensis* (Brit. Mus. Cat., pt. iii. p. 6, pl. iv. figs. 7–11), but in this species the spinous process thus formed is much more obtuse, and there are other differences which prevent their being considered the same.

(6) *Crisia acropora*, Busk.

Crisia acropora, Bk., Voy. of Rattles., vol. i. p. 351; Brit. Mus. Cat., pt. iii. p. 6, pl. v. figs. 3–4; Macgilliv., *loc. cit.*, Dec. iv. p. 38, pl. xxxix. fig. 3.

Character.—Cells nine to thirteen in each internode; a conical tooth (sometimes bifid) behind the orifice. Zoœcia slightly compressed; surface closely punctured, brilliant, sometimes porcellanous. Branches arising from the second to the fourth zoœcium. Oœcial cells large, pyriform, frequently annulated. Branches 0·25 mm., and zoœcia about 0·06 mm. wide.

Habitat.—Station 161, off Port Philip, 33 fathoms, sand.

[Bass Strait, R.; Williamstown and Queenscliff, Macgilliv.]

In this species the radical tubes are much curled, always arising from the bottom of the lowest cell in an internode, behind.

(7) *Crisia holdsworthii*, Busk (Pl. III. fig. 2, oœcium).

Crisia holdsworthii, Busk, Brit. Mus. Cat., pt. iii. p. 7, pl. vi.B fig. 2.

Character.—Zoœcia nine to eleven in each internode, connate throughout, with a short, tubular, cylindrical prolongation projecting directly forwards; walls very delicate, sparsely punctured; branches arising usually from the third, but in the lower internodes

not unfrequently from the second cell. Oœcial cell infundibuliform, rounded at the top. Branches 0·2 mm., and zoœcia 0·08 mm. wide.

Habitat.—Off Marion Island, 50 to 75 fathoms; off Prince Edward Island, 80 to 150 fathoms.

[Ceylon, Holdsworth.]

Habit very delicate and slender. May be allied to *Crisia tenuis*, Macgilliv. (*loc. cit.*, p. 39, pl. xxxix. fig. 5), in which, however, the zoœcia appear to be less closely connate. In the specimens brought by Mr. Holdsworth from Ceylon there were no oœcia; on which account I have given a figure of that organ from the Challenger collection.

(8) *Crisia conferta*, Busk (Pl. II. fig. 5).

Crisia conferta, Bk., Brit. Mus. Cat., pt. iii. p. 7, pl. vi.A fig. 5.

Character.—Zoarium tufted, composed of short, thick, curved branches radiating as it were from a short central stem. Zoœcia thirteen to twenty-one in an internode; nearly the upper half free, cylindrical, curved abruptly forwards; orifice orbicular or subelliptical, of the same diameter as the tube; branches one to four from each internode, not opposite. Oœcial cells closely adnate, median or axilliary; usually broadly truncate. Branches 0·35 mm., and zoœcia 0·07 mm. wide.

Habitat.—Off St. Vincent, Cape de Verde Islands, depth 10 fathoms. Station 163A, off Twofold Bay, 150 fathoms.

[Cape de Verde Islands, H.M.S. "Herald."]

A well-marked species, growing usually in dense tufts, and peculiar for the number of branches springing from an internode. The curved free portion of the cell is not, as is most usually the case, a mere production of the peristome marked with annular lines of growth, since the wall of that part is punctured like the rest of the zoœcium.

(9) *Crisia cylindrica*, n. sp. (Pl. II. figs. 2, 4).

Character.—Zoarium about $\frac{1}{2}$ an inch high, furcately branched; ten to thirty zoœcia in an internode; usually two branches given off from the longer segments, the lower from about the seventh zoœcium, and the upper near the summit of the internode. Zoœcia about half immersed, the upper part curved forwards, exceedingly delicate and thin-walled, without puncta; orifice circular, margin even. Branches perfectly cylindrical, with an even shiny surface, distinctly punctate; dorsal aspect obliquely striated, but quite even. Oœcial cells pyriform, usually axillary, with a wide tubular orifice. Diameter of branches about 0·15 mm., and of zoœcia 0·06 to 0·08 mm.

Habitat.—Off Nightingale Island, Tristan da Cunha, 100 to 150 fathoms.

A beautifully delicate form, distinguishable by its very slender habit and the perfectly cylindrical aspect of the branches, with the projecting cylindrical zoœcia, the projecting portion wholly oral. Its nearest ally would be *Crisia holdsworthii.*

Division II.—INARTICULATA.

Centrifuginés empâtés à cellules non operculées, d'Orb., Palæont. Franç., p. 605 (pars).
Inarticulatæ seu affixæ, Bk., Crag Polyzoa, p. 93.
Incrustata, d'Orbigny, Smitt.

Character.—Zoarium continuous, not divided into distinct internodes, fixed by a contracted calcareous base, either erect and free, or immediately adnate upon foreign bodies, and recumbent in whole or in part.

Subdivision A. ERECTA.

Family II. Idmoneidæ, Busk.

Tubigeridæ (pars), d'Orbigny, *loc. cit.*, p. 698.
Tubuliporidæ (pars), Johnst., Smitt, Hincks.
Les Tubuliporiens (pars), Milne-Edwards.
Idmoneidæ, Bk., Crag Polyzoa, p. 94; Brit. Mus. Cat., pt. iii. p. 10; Macgilliv.
Idmoneadæ, Bk., Engl. Cyclopedia, art. Polyzoa.
Horneridæ, Hincks.

Character.—Zoarium usually erect and rarely adnate, simple or branched; branches cylindrical, subcylindrical, or triangular, free or anastomosing.

The Family here contains the following genera:—

1. *Idmonea*, Lamx.

§ α. The zoœcia all disposed in alternate series on each side of the front of the branches; the innermost the longest.

(1) *Idmonea atlantica,* E. Forbes.
(2) *Idmonea radians,* Lamk.
(3) *Idmonea marionensis,* Busk.
(4) *Idmonea australis,* Macgilliv. (Pl. III. fig. 3).
(5) *Idmonea eboracensis,* n. sp. (Pl. III. fig. 4).

§ *β*. The outermost zoœcia in the lateral series the longest; isolated zoœcia opening in the space on the front between the lateral series.

(6) *Idmonea milneana*, d'Orb.
(7) *Idmonea irregularis*, Meneghini.
(8) *Idmonea fissurata*, n. sp. (Pl. III. fig. 5).

2. *Hornera*, Lamx.

§ *a*. Zoarium branched, branches free or rarely inosculating.

§§ *a*. Oœcia dorsal; anterior surface of branches reticulato-fibrillate.

(1) *Hornera frondiculata*, Lamx.
(2) *Hornera lichenoides*, Linn.

§§ *b*. Oœcia anterior, either wholly or in part; surface in front not fibrillated or sulcate.

(3) *Hornera violacea*, Sars.

§ *β*. Zoarium foliaceous, branches connected by transverse tubules.

(4) *Hornera foliacea*, Macgilliv.

3. *Pustulopora*, Blainv.

(1) *Pustulopora proboscidea* (Pl. IV. fig. 1).
(2) *Pustulopora proboscidioides*, (Pl. IV. fig. 4).
(3) *Pustulopora deflexa*, Smitt (Pl. IV. fig. 3).
(4) *Pustulopora regularis*, Macgilliv. (Pl. IV. fig. 2).

1. *Idmonea*, Lamouroux.

Idmonea, Lamx., Exp. Méth., p. 80; Defrance, Blainville, M.-Edwards, Johnst., Lonsdale, Reuss, Michelin, Hagenow, d'Orb, 1852 (pars); Busk, Van Beneden, Hincks, Smitt (subgenus), &c.
Crisia (pars), d'Orbigny, Stoliczka.
Retepora (pars), Goldfuss, Lamk.
Diastopora (pars) Michelin.
Tubulipora (pars), Lamk., Smitt.
Crisina (pars), d'Orbigny, Smitt.

Character.—Zoarium erect, free or very partially adnate, branched dichotomously or irregularly; springing from a single tubular cell, having a constricted, basal, discoid expansion. Branches free or anastomosing; orifices of zoœcia disposed in parallel or subparallel, transverse or oblique, usually alternate series on the sides of the front of the

branches, which are usually flattened behind, and either angular or rounded on the anterior aspect.

§ *a.* The zoœcia all disposed in alternate series on each side of the front of the branches; the innermost the longest.

(1) *Idmonea atlantica*, E. Forbes.

Idmonea radians, Van Beneden, Bryoz. de la Mer du Nord, Bull. Brux., xvi. pt. ii. p. 646, pl. i. figs. 4, 6.

? *Idmonea coronopus*, Defrance, Dict. d. Sci. Nat., vol. xxii. p. 565; d'Orbigny, Milne-Edwards, Réch. sur les Crisies, p. 23, pl. x. fig. 3.

Idmonea atlantica, E. Forbes, MSS., Smitt, Johnst., Gray, Sars, Busk, Ann. and Mag. Nat. Hist., ser. 2, vol. xviii. p. 34, pl. i. figs. 6*a–e*; Quart. Journ. Micr. Sci., vol. vi. p. 128, pl. xviii. fig. 5; Rep. Brit. Assoc., 1859 (Trans. Sect.) p. 146; (var. *tenuis*) Brit. Mus. Cat., pt. iii. p. 11, pl. ix.; Smitt, Florid. Bryoz., p. 6, pl. ii. figs. 7, 8; Hincks, Waters, &c.

? *Idmonea angustata*, d'Orb., Palæont. Franç., p. 731.

Character.—Zoarium irregularly branched and usually more or less in one plane; branches triangular, one to four or five cells in each series, the innermost the longest; dorsal surface very minutely punctate; peristome entire, even. Oœcium anterior, subpyriform.

Habitat.—Off Nightingale Island, 100 to 150 fathoms. Station 149E, off Cape Maclear, Kerguelen, 30 fathoms. Simon's Bay, Cape of Good Hope, 18 fathoms.

[Arctic Seas; coast of Norway and Finmark; Shetland; var. *tenuis*, North Atlantic; Gulf of Florida, Smitt; Madeira (?), Bay of Naples; fossil in Italian Miocene and Canadian Post Pliocene (?).]

(2) *Idmonea radians*, Lamarck (sp.).

Retepora radians, Lamk., d'Orbigny.

Idmonea radians, Busk., Brit. Mus. Cat., pt. iii. p. 11, pl. vii. figs. 1–4; Macgilliv., Nat. Hist. Vict., Dec. vii. p. 30, pl. lxviii. fig. 3; Waters; Haswell, Proc. Linn. Soc. N. S. Wales, vol. iv. p. 350, vol. v. p. 35.

? *Hornera radiata*, Blainv., Man. d'Actin., p. 419.

Idmonée rayonnante, M.-Edw., *loc. cit.*, p. 25, pl. xii. fig. 4.

Character.—Zoarium usually procumbent, radiate in a more or less regular circle, stipitate, sometimes suberect, with elongated, straight, subparallel bifurcating branches. Branches keeled in front, rounded behind. Dorsal aspect longitudinally sulcate, with a series of long perforations or alveoli along the sulci; the sides and front pitted, sometimes almost reticulate. Zoœcia produced, gently curving forwards, somewhat tapering, often with a bilabiate orifice, about 0·06 mm. Branches 0·3 mm., series about 0·4 mm. apart. Usually only one or two zoœcia on the sides of the front, alternate, when more than one the inner one the longer. Oœcial chambers subglobular on the anterior aspect, close below, but not at a bifurcation; surface coarsely pitted or foveolate.

Habitat.—Station 172, off Tongatabu, 18 fathoms, coral mud. Off Honolulu, 20 to 40 fathoms.

[Australian Seas *ubique*, New Zealand, &c.]

This species appears to occur under two rather distinct forms. In one (the typical) it constitutes a beautiful circular expansion, about one inch or more in diameter, composed of short bifurcating branches radiating from a central short stem (*vide* Brit. Mus. Cat., pt. iii. pl. vii. fig. 1*a*), or a more straggling growth in which the branches, though still springing from a more or less excentric point, are much longer, forming elongated forks (*loc. cit.*, fig. 1*b*), constituting a variety to which the term *stricta* might be applied. Very fine specimens of this form occur in the Challenger collection, from Honolulu, whilst a beautiful specimen of the radiate type was procured at Station 172, off Nukalofa, Tongatabu.

In all the Challenger specimens there is rarely more than one zoœcium to represent the lateral series, but in others there are occasionally as many as four (*vide* Brit. Mus. Cat., pt. iii. pl. vii. fig. 4), as described by Mr. Macgillivray. The great peculiarity of the species, however, is seen in the coarsely pitted or foveolate surface on the sides of the branches, and the series of large pores or pits along the dorsal sulci; the oœcial chambers also have peculiar sculpture.

(3) *Idmonea marionensis*, Busk.

> *Idmonea marionensis*, Busk, Brit. Mus. Cat., pt. iii. p. 13, pl. xiii. figs. 3, 5; pl. vii. figs. 7, 8 (young state); Waters, Haswell.
>
> ? *Crisina hochstetteriana*, Stoliczka, "Novara" Exp. Geol., Theil, Bd. i. p. 113, Taf. xviii. fig. 3; Smitt, Florid. Bryoz., p. 6, pl. ii. figs. 11–13.

Character.—Zoarium slender, elongate, very sparingly branched; stem and branches cylindrical or subcylindrical. Zoœcia two to four in each series (most usually two) about 0·15 to 0·20 mm., series wide apart, 0·7 to 0·8 mm., when entire the innermost the longest. Surface finely but sparsely punctured; dorsal surface convex, with a fine longitudinal striation.

Habitat.—Off Marion Islands, 50 to 75 fathoms; off Prince Edward Islands, 80 to 150 fathoms. Station 147, lat. 46° 16′ S., long. 48° 27′ E., 1600 fathoms, Diatom ooze. Station 151, off Heard Island, 75 fathoms, volcanic mud. Station 320, lat. 37° 17′ S., long. 53° 52′ W., 600 fathoms, green sand.

[? Auckland, New Zealand, fossil, Stoliczka; Bay of Naples and Marion Islands, Waters; Queensland, Haswell.]

As I have remarked in Brit. Mus. Cat., this species seems to mark a transition between *Pustulopora* and *Idmonea*. The cells, however, are always disposed in rows or series on each side of the anterior aspect of the branch, and are for the most part deeply immersed;

the exserted portion being of a very thin and delicate texture rarely shows the orifice in a perfect condition. It may perhaps be identical with M. d'Orbigny's *Idmonea canariensis* (Palæont. Franç., p. 732); but as neither figure nor sufficient description of that species are given, and it is merely stated to be "slender as a thread and almost round, with very few cells," it is impossible to be certain.

(4) *Idmonea australis*, Macgillivray (Pl. III. fig. 3).

Idmonea australis, Macgilliv., *loc. cit.*, Dec. vii. p. 30, pl. lxviii. fig. 2.

Character.—Zoarium of small size ($\frac{1}{2}$ to $\frac{3}{4}$ inch), irregularly branched once, each short branch terminating in a single fork; branches contorted and sometimes twisted; four to six zoœcia in each series, the inner the longest; no intermediate longitudinal space in front between the series. Zoœcia very slender (0·12 mm.), connate below, but when perfect much produced or free for one-half or two-thirds of their length, slightly tapering, some nearly straight and ascending obliquely, but towards the upper part of the branches curved forwards, not flattened in front; series 0·7 to 1·0 mm. apart. Branches compressed, rounded both in front and behind, about 0·6 mm. wide, everywhere minutely dotted, up to the border of the aperture; dorsal surface very finely striated longitudinally, intermediate spaces with very minute dots in irregular longitudinal series.

Habitat.—Station 163B, off Port Jackson, 30 to 35 fathoms, rock. Off Marion Island, 50 to 75 fathoms.

[Port Phillip Heads, 10 to 15 fathoms, Macgilliv.]

A very distinct and well-marked species, easily recognisable by the compressed form of the branches, which on section are oval, as well as by the extremely fine punctation, or rather white dotting of the surface, and the fine or close longitudinal striation of the dorsal aspect. It appears to vary very much in the length of the exserted portion of the zoœcia, which, in the specimens from Marion Island, forms more than half the length of the cell (Pl. III. fig. 3). The exserted part is very slightly tapering and no part of it appears to be peristomal, as the wall exhibits the minute punctation quite up to the orifice, and there is very rarely any appearance of annular lines of growth. None of the specimens present any oœcial chamber.

Mr. Macgillivray suggests that this species may prove to be a form of *Idmonea atlantica*, but for this view I can see no grounds whatever.

(5) *Idmonea eboracensis*, n. sp. (Pl. III. fig. 4).

Character.—Zoarium very small, not more than $\frac{1}{4}$ inch high; branches very short and irregular, once furcate, much compressed, 0·6 mm. wide; dorsal aspect rounded, longitudinally striated but not grooved. Striæ (fig. 4*c*), about 0·01 mm. apart, a single irregular

row of dots down each interspace. Zoœcia (0·1 mm.), usually four in each series, of uniform length, except the innermost, which is the longest; series 0·4 to 0·5 mm. apart.

Habitat.—Station 186, off Cape York, 8 fathoms, coral mud.

The collection affords only a single such specimen, but apparently mature, inasmuch as two of the branches are widely dilated at the second bifurcation into an elongated, deeply immersed oœcial chamber.

§ *β.* (subgenus *Tervia*).—The outermost zoœcium in each lateral series the longest; scattered zoœcia opening irregularly in the space between the lateral series.

Tervia, Jullien, Bull. Soc. Zool. de France, vol. vii. p. 500, 1882.

(6) *Idmonea milneana*, d'Orbigny.

Idmonea milneana, d'Orb., Voy. d. l'Amér. Mérid., "Polypiers" p. 20, pl. ix. figs. 17–21; Palæont. Franç., p. 732; Smitt, Florid. Bryoz., p. 8, pl. iii. figs. 14–17; Macgilliv., *loc. cit.*, Dec. vii. p. 29, pl. lxviii. fig. 1; Busk, Brit. Mus. Cat., pt. iii. p. 12, pl. xi.; Waters, Haswell, Ridley.

? *Idmonea transversa*, Milne-Edw., *loc. cit.*, p. 26, pl. ix. fig. 3

Character.—Zoarium spreading from a central peduncle, branching dichotomously. Branches depressed, broad, flattened or slightly rounded behind, 0·8 to 1·5 mm. wide; surface thickly punctate; on dorsal aspect irregularly striated longitudinally, and, except in the younger part, transversely wrinkled. Zoœcia about 0·2 mm. in diameter, usually four or more in a series, the outer the longer; a few intermediate zoœcia opening in the space in front between the lateral series; series 0·6 to 1 mm. apart. Oœcial chamber?

Habitat.—Station 75, lat. 38° 38′ N., long. 28° 28′ 30″ W., 450 fathoms, volcanic mud. Station 151, off Heard Island, 75 fathoms, volcanic mud. Off Prince Edward Island, 80 to 150 fathoms.

[Port Philip Heads, 10 to 15 fathoms, Macgilliv.; Falkland Islands, d'Orbigny; coast of Tierra del Fuego, and Patagonia, 30 fathoms; Chonos Archipelago, Darwin; Port Jackson and Queensland, Haswell.]

The cells, as Mr. Macgillivray observes, are usually four in series, the inner the least prominent, the others gradually increasing in length to the outer, which projects very much. They are united side to side throughout almost their whole length, so as to form regular walls, rising up and projecting far beyond the sides of the branches. As in several other species of *Idmonea* numerous radical tubes are given off from the back of the branches by which the growth is attached. The anterior median single zoœcia are few in number and usually nearly level with the surface. *Idmonea milneana* belongs to the group for which M. Jullien has proposed the name of *Tervia*, characterised by the

possession of an intermediate or azygos set of zoœcia on the front, and, it may be added, by the circumstance that the outermost zoœcium in the lateral series is the longest.

(7) *Idmonea irregularis*, Meneghini.

Idmonea irregularis, Meneghini, Mém. sui. Polypi della Famiglia Tubuliporiani, p. 12 (*teste* Heller); Heller, Adriat., p. 121; Busk, Brit. Mus. Cat., pt. iii. p. 13, pl. xii.; Waters, Haswell.
? *Tervia folini*, Jullien, Bull. Soc. Zool. de France, vol. vii. p. 501, pl. xiii. figs. 8–9, 1882.

Character.—Zoarium composed of irregularly dichotomous, slender, rounded branches, 0·5 to 0·6 mm. wide. Zoœcia four to six in each lateral series, and the intermediate space in front occupied by numerous others irregularly scattered; series 0·6 to 0·8 mm. apart. Diameter of zoœcia 0·1 to 0·15 mm.; surface uniformly and thickly punctate; dorsum with longitudinal striæ wide apart. Oœcial chamber?

Habitat.—Station 75, lat. 38° 38′ N., long. 28° 28′ 30″ W., 450 fathoms, volcanic mud.

[Adriatic, Meneghini, Heller; Mediterranean, H.M.S. "Porcupine"; Bay of Biscay, Jullien; Bay of Naples, Waters; Queensland, Haswell.]

(8) *Idmonea fissurata*, n. sp. (Pl. III. fig. 5).

Character.—Zoarium procumbent, composed of branches radiating irregularly from a central peduncle, dividing about twice dichotomously and appearing strongly serrated on the borders; branches 0·7 to 1 mm. wide. Zoœcia 0·15 to 0·2 mm. in diameter, with an elliptical aperture, closely adnate, the outermost the longest; a few isolated median zoœcia whose apertures are usually level with the surface. Lateral series 0·9 to 1·1 mm. apart. Surface of branches in front and behind deeply and irregularly sulcate and pitted.

Habitat.—Station 320, lat. 37° 17′ S., long. 53° 52′ W., 600 fathoms, green sand.

This species is at once recognisable by the peculiar fissured aspect of the surface, both in front and behind, and the numerous irregular pits with which it is studded. Its habit in some specimens is something like that of *Idmonea radians*, but much stronger. Like the others of the group to which it belongs, the branches appear serrated on each side.

2. *Hornera*, Lamouroux.

Hornera, Lamx., Expos., p. 41 (1821); Milne-Edwards (pars), Reuss (pars), Blainville (pars), Defrance, Michelin, Hagenow, d'Orbigny, Smitt, Hincks, Busk, Sars, &c.
Millepora (pars), Linné, Pallas, Esper, Solander.
Retepora (pars), Lamarck, Goldfuss.
Syphodictyum (pars), Lonsdale.

Character.—Zoarium ramose or foliaceous; zoœcia opening only on one side; oœcia dorsal or anterior.

§ *a*. *Ramosa.*—Zoarium branched, branches free or rarely inosculating, cylindrical or subcompressed.

§§ *a*. Oœcia dorsal; anterior surface of branches reticulato-fibrillate.

(1) *Hornera frondiculata*, Lamouroux.

Hornera frondiculata, Lamx., Exp., p. 41, pl. lxxiv. figs. 7–9; Milne-Edwards, *loc. cit.*, p. 17, pl. ix. figs. 1–1*c*.; Blainville, Man. d'Actin., p. 419; Heller, Adriat., p. 124; Busk, Brit. Mus. Cat., pt. iii. p. 17, pl. xx. figs. 1, 2, 3, 6; Manzoni, Waters.
Millepora tubipora, Ell. and Soll, p. 139, pl. xxxi. fig. 1.
Millepora lichenoides, Linné, Pallas, Esper.
? *Hornera affinis*, M.-Edw., *loc. cit.*, p. 9, pl. x. fig. 1.
? *Hornera andegavensis*, Mich., Icon. Zooph., p. 318, pl. lxxvi. fig. 8.
Hornera serrata et tubulosa (?), Meneghini, *loc. cit.*, p. 10.

Character.—Branches tapering, ramifying more or less in one plane, cylindrical or subcompressed; anterior surface strongly fibro-reticulate, divided into rhomboidal spaces in which are situated the orifices of the zoœcia, surrounded with numerous small pores. Orifice exserted, usually bifid; dorsal surface coarsely reticulate, granular or nearly smooth, with small elongated pores in the sulci. Oœcia oblong, carinate, ribbed; aperture tubular, superior. Diameter of branches about 0·6 mm., and of orifice 0·08 mm.

Habitat.—Porto Praya, St. Iago, Cape de Verde, 100 to 120 fathoms.

[Mediterranean, Adriatic (very abundant). Fossil in the Crag and Upper Tertiaries of Sicily, &c.]

(2) *Hornera lichenoides*, Linné (sp.).

Corallium, Pantoppidan, Norg. Natuurb., vol. i. p. 258, pl. xiv. figs. D.E.
Millepora lichenoides, Linné, Müller, Prodr., p. 252, No. 3046; Ström, Act. Hafn., vol. xii. p. 309, pl. iii. fig. 12; Fabricius, Zool. Samml. (*teste* Smitt), and Fauna Grœnl., p. 432 (*nec* Pallas).
Hornera frondiculata, Sars, Reise, Löf. oz Finm. nyt Magazin f. Nat. Vid., t. vi. p. 146; Busk, Ann. and Mag. Nat. Hist., ser. 2, vol. xviii. p. 34, pl. i. fig. 7*a*.
Hornera borealis, Busk, Crag Polyzoa, pp. 95–103; Alder, New British Polyzoa, Quart. Journ. Micr. Sci., N.S., vol. iv. p. 108, pl. v. figs. 1–6.
Hornera lichenoides, Smitt, Kritisk Förteckn., pp. 404, 469, pl. vi. fig. 10, pl. vii. figs. 1–14; Busk, Brit. Mus. Cat., pt. iii. p. 17. pl. xviii. figs. 5–6; Hincks, Brit. Mar. Polyz., p. 468, pl. lxvii. figs. 1–5.

Character.—Zoarium rising from a rather thick furrowed base, branched irregularly; branches dichotomous, crowded and straggling, often spreading out in a flabelliform

manner. Anterior surface obscurely fibro-reticulate, sparsely furnished with subtubular pores. Zoœcia on the front of the branches, immersed or very slightly prominent, those of the outer sides of the branches tubular, slightly expanded towards the orifice, which is more or less elliptical, with an entire border often much produced on one side; dorsal surface finely sulcate with minute pores in the sulci. Oœcia dorsal, subglobular or gibbous, the surface reticulate or coarsely punctured. Aperture tubular, lateral (from which a very slender rib stretches across to the opposite side, Hincks). Diameter of branches 0·5 to 0·6 mm., and of orifice about 0·1 mm.

Habitat.—Station 320, lat. 37° 17′ S., long. 53° 52′ W., 600 fathoms, green sand.

[Arctic Seas, Lovén; coasts of Scandinavia, Pantoppidan, Sars, Macandrew; Shetland, Barlee; Hebrides, Norman; Nova Zembla; Greenland, Lütken; St. Georges Banks, Smitt and Harger.]

§§ *b.* Oœcia anterior, either wholly or in part; dorsal surface granular or finely striate.

(3) *Hornera violacea*, Sars.

Hornera violacea (*forma violacea*), Smitt, *loc. cit.*, p. 404, Tab. vi. fig. 6–9; Sars, Geol. og. Zool. Jagtt Reise, Jaondj., 1862, Nyt Magaz. Nat. Vid., vol. xii. p. 282; Busk, Brit. Mus. Cat., pt. iii. p. 18, pl. xviii. figs. 1–4; Norman, Shetl. Dredg. Rep. Brit. Assoc., 1867, p. 310; Hincks, Brit. Mar. Polyz., i. p. 469, pl. lxvii. figs. 6–8, pl. lxii. figs. 2, 3.

Pustulopora orcadensis, Bk., Quart. Journ. Micr. Sci., 1860, vol. viii. p. 214, pl. xxxix. figs. 1, 2.

Character.—Zoarium more or less of a violet colour, branched, straggling; branches short, truncate, irregularly dichotomous. Zoœcia very irregularly disposed, sometimes crowded into small fasciculi, usually elongated; surface punctate (not reticulate); dorsal surface granular, or very finely striated with minute pores, often a rib-like elevation down the centre of the branch. Oœcia elongated, situated in the axils of the branches, usually more towards the dorsal aspect; surface smooth, finely punctate, with a thin median costa; orifice bilabiate near the top. Diameter of branches 0·4 to 0·7 mm., and of orifice 0·12 mm.

Habitat.—Station 151, off Heard Island, 75 fathoms, volcanic mud.

[Arctic and Northern Seas, generally distributed; Shetland.]

§ *β. fenestrata* (subgenus *Retihornera*).—Branches sub-parallel, connected by transverse tubules, so as to form an expanded frond with quadrangular fenestræ.

Retihornera (pars), Kirchenpauer, Cat. iv. of the Museum Godeffroy, 1869; Busk, Brit. Mus. Cat., pt. iii. p. 19.

(4) *Hornera foliacea*, Macgillivray.

Hornera foliacea, Macgilliv., Proc. Roy. Soc. Vict., vol. ix., p. 142, 1868.
Retihornera foliacea, Busk, Brit. Mus. Cat., pt. iii., p. 19, pl. xiii. figs. 1, 2, and pl. xix.; Haswell.
? *Retihornera dentata*, ? *Retihornera plicata*, Kirchenpauer.

Character.—Zoarium expanded, foliaceous, irregularly plicate or convoluted, rising from a short stem with a discoid base; main branches straight, parallel, connected by numerous transverse celliferous branches or trabeculæ, forming quadrangular fenestræ of pretty uniform size, from 0·7 to 2 mm. in length by 0·3 to 0·4 mm. wide, or about the width of the branches. Zoœcia in the young state exserted, with a usually bifid or toothed orifice, about 0·05 mm. in diameter. In the older condition more immersed, with an irregularly bifid or toothed, thickened, somewhat expanded orifice. Anterior surface fibro-reticulate, obscurely punctate and uneven; posterior sulcate, granular, obscurely punctured or pitted. Oœcia subglobose, dorsal; usually three zoœcia in the width of a branch, and one in a trabecula.

Habitat.—Station 161, off Port Phillip, 33 fathoms, sand. Station 163B, off Port Jackson, 35 to 38 fathoms, rock.

[South Australia, Gould, Macgillivray, Queensland, Haswell.]

Although at one time inclined to regard the fenestrate form of *Hornera* as entitled to the rank of a distinct genus or subgenus, I no longer regard it as forming more than a subgenus, as in all essential characters it perfectly agrees with such forms as *Hornera lichenoides*, *Hornera frondiculata*, and *Hornera cæspitosa*, Mihi., differing as do those species from *Hornera vidacea* in having the anterior aspect fibro-reticulate, and the oœcia dorsal. In the Brit. Mus. Cat., pt. iii., p. 19, I have described *Hornera foliacea* as being furnished with delicate spiculæ projecting from the sides of the fenestræ, but it is highly probable that these are merely the spiculæ of some parasitic encrusting Sponge; in all other respects the form brought by Mr. Gould from South Australia in my collection, from which the account in the Brit. Mus. Cat. was drawn up, exactly agrees with the specimens in the Challenger collection, which again are undoubtedly the *Hornera foliacea* of Mr. Macgillivray. In one of the specimens is a shallow, circular, cup-shaped depression on the dorsal aspect, doubtless the remnant of an oœcium, but these organs would appear to be very rare.

3. *Pustulopora*, Blainville.

Pustulopora, Blainville (text), Man. d'Actin., p. 418, 1834; Milne-Edwards, Hagenow (*nec* Geinitz), Reuss, Michelin (?), Grube, Meneghini; Busk, Brit. Mus. Cat., pt. iii. p. 20, &c.; Macgilliv., Proc. R. Soc. Vict., December 1880, p. 6.

Pustulipora, Blainv. (index), Johnston, Gray, Sars, Joliet.

Tubulipora (pars), Couch.

Entalophora (pars), d'Orbigny (*nec* Lamouroux), Hincks, Brit. Mar. Polyz., p. 455; Smitt, Florid. Bryoz., vol. i. p. 11; Stoliczka, Waters, &c.

Character.—Zoarium erect, simple or branched, cylindrical; branches irregular, composed of tubular zoœcia partially or wholly connate or immersed; opening on all sides of the branch, and disposed quincuncially or irregularly, sometimes in more or less annular or subspiral order.

Although most recent writers, including such high authorities as Professor Smitt and Mr. Hincks, have adopted the name *Entalophora* for the genus here intended, I am inclined, with the greatest deference, to prefer M. de Blainville's and M. Milne-Edwards' name, for the reason that the species named *Entalophora* by Lamouroux appears to me to differ in at least one most important respect, it may be said, from all the other known Cyclostomata, and most certainly from all with which I am acquainted, either recent or fossil, viz., in the appendages, as he terms them, being trumpet-shaped, or gradually increasing in diameter as they increase in length. Whether this arises from an error of observation on the part of Lamouroux or of his draughtsman, or is the true condition, may perhaps admit of doubt; with the exception of M. Michelin (Iconog., pl. lvi. fig. 4), whose figure very strongly resembles that of Lamouroux, no one seems to have recorded any other form with trumpet-shaped tubes, and as even his figure does not represent them as having that form, I am much inclined to assume that Lamouroux's specimen is unique in that respect, and if correctly figured and described, that it must on that account alone be referred to a distinct generic type from all other known Pustuloporidæ, and in fact, as above observed, from all other Cyclostomata. (May it not be a coralline?).

On the other hand, M. de Blainville's definition of *Pustulopora*, as distinguished from Lamouroux's *Entalophora*, is so clear and precise, and his genus has met with the acceptance of M. Milne-Edwards, Hagenow, Reuss, and numerous others, and in fact may be said, until quite recently, to have been in full possession of the field, that I feel no hesitation in retaining it for all forms with cylindrical tubes of the same diameter throughout; and in relegating those forms, if there really be any, with trumpet-shaped tubes, to at least a distinct genus.

With respect to the spelling of the name there can be no doubt that *Pustulopora* is the correct way, *Pustulipora* being apparently merely a printer's error in the index to the Manuel d'Actinologie. In the text (*loc. cit.*) M. de Blainville has it *Pustulopora*. Mr. Macgillivray has passed over a similar misprint (*loc. cit.*) the name being spelled *Pustulopera* in the text and *Pustulopora* in the description of the plates.

(1) *Pustulopora proboscidea*, Milne-Edwards (Pl. IV. fig. 1).

Pustulopora proboscidea, M.-Edw., Sur les Crisies, p. 27, pl. xii. fig. 2; Heller, Adriat., p. 125; Grube, die Insel Lussin, p. 68; Busk, Brit. Mus. Cat., pt. iii. p. 21 (*nec* pl. xviii.A); Haswell.

Pustulipora proboscidea, Johnst., p. 279, pl. xlviii. fig. 4; Gray.

Entalophora proboscidea, Waters, Bryoz. of the Bay of Naples, Ann. and Mag. Nat. Hist., ser. 5, vol. iii. p. 274 (1879); Vine.

To these Mr. Waters, Fossil Cyclostomatous Polyzoa from Australia, Quart. Journ. Geol. Soc., vol. xl., 1884, p. 686, adds the following fossil forms:—

Entalophora raripora, d'Orb., Prod. Pal. Strat., p. 267; Palæont. Franç., p. 787, pl. dcxxi. figs. 1–3, pl. dcxxiii. figs. 15–17; Beissel, Bryoz. Aach. Kreid., p. 82, pl. x. figs. 120–128.

Pustulopora virgula, Hagenow, Maast. Kreid., p. 17, pl. i. fig. 3.

Entalophora icaunensis, d'Orb., Palæont. Franç., p. 781, pl. dcxvi. figs. 12–14.

Entalophora attenuata, Stol., Bry. von Latdorf., p. 77, pl. i. fig. 1; Reuss (?), Bry. Crosaro, p. 74, pl. xxxvi. figs. 1, 2.

Entalophora anomale, Manzoni, Bry. Mioc. Aust. ed Ungh., p. 10, pl. ix. fig. 33.

Entalophora haastiana, Stol., Bry. Ora. Bay., p. 102, pl. xvii. figs. 4, 5.

Character.—Zoarium composed of long, straight, alternate, furcate, cylindrical branches, 0·4 to 0·9 mm. in diameter, constituted usually of four longitudinal alternate series of zoœcia which are exserted for about one-third of their length, the exserted tube curving outwards nearly at a right angle and constituted mainly of a peristomal production, ringed, thin, not punctate, with an entire circular orifice about 0·15 mm. in diameter; surface elsewhere finely punctate. Oœcia consisting apparently of a terminal expansion, or of one situated close to a bifurcation.

Habitat.—Station 151, off Heard Island, 75 fathoms, volcanic mud. Off Prince Edward Island, 80 to 150 fathoms.

[Shetland (?), E. Forbes; Mediterranean, Milne-Edwards; Adriatic, Heller; Naples, Waters; Teneriffe and Canaries, d'Orbigny; Madeira, I. G. I.; Gulf of Florida, Smitt; Port Jackson and Queensland, Haswell.]

With respect to the Shetland locality assigned to this species in the Brit. Mus. Cat. on the authority of E. Forbes, as its occurrence in that locality is not noticed either by Mr. Norman or by Mr. Hincks as a British form, and, moreover, is omitted by Professor Smitt in Lists of Scandinavian or Arctic Polyzoa, it is highly probable that some mistake has arisen. It would appear to be a Mediterranean and Atlantic form, extending as far south as the Kerguelen region.

(2) *Pustulopora proboscidioides*, Smitt (sp.) (Pl. IV. fig. 4).

Entalophora probosidioides, Smitt, Florid. Bryoz., vol. i. p. 11, pl. iv. figs. 26, 27.

Character.—Zoarium composed of elongated, forked, cylindrical branches, 0·7 to 1 mm. in diameter, constituted of about six longitudinal series of zoœcia, almost entirely immersed, except a short, cylindrical, exserted portion with a circular orifice, about

0·17 to 0·2 mm., which are disposed irregularly in circular whorls, about 1 mm. apart; surface rough, punctate, even, with very faint indication of longitudinal striation.

Habitat.—Off Marion Island, 50 to 75 fathoms.

(3) *Pustulopora deflexa*, Smitt (sp.) (Pl. IV. fig. 3).

Entalophora deflexa, Smitt, Florid. Bryoz., vol. i. p. 11, pl. v. figs. 28–30; Waters, Ann. and Mag. Nat. Hist., ser. 5, vol. iii. p. 274.
Pustulipora deflexa, Johnst., p. 279, pl. xlviii. fig. 5; Norman, Rep. Brit. Assoc., 1868, p. 310; Marion, Ann. d. Sci. Nat., sér. 6, t. viii. p. 1; Joliet.
Pustulopora deflexa, Heller, Adriat., p. 125.
? *Tubulipora deflexa*, Couch, Corn. Fauna, vol. iii. p. 107, pl. xix. fig. 4.
? *Stomatopora deflexa*, Hincks, Brit. Mar. Polyz., p. 437, pl. lvii. fig. 4.
? *Pustulopora clavata*, Busk, Crag Polyzoa, p. 107, pl. xvii. fig. 1.

Character.—Zoarium composed of very irregular furcate branches, 1 to 1·2 mm. in diameter, constituted of very long cylindrical or very slightly terete ascending zoœcia, often crowded together in fasciculate bundles and varying greatly in length; slightly produced orally, the produced portion curving slightly outwards; surface granular or uneven, sometimes transversely rugose, about 0·2 mm. in diameter. Oœcia ?

Habitat.—Station 151, off Heard Island, 75 fathoms, volcanic mud.

[South coasts of Britain; Shetland, Norman; Gulf of Florida, Smitt; Bay of Naples, Waters; Adriatic, Heller; Marseilles, Marion; Roscoff, Joliet.]

A peculiar feature of this species is the great disposition of the zoœcia to be collected into fasciculate bundles, somewhat in the same way apparently as they are described by Mr. Hincks in his *Stomatopora fasciculata*, from which, however, it differs in other more important particulars, such as the perfectly free and erect habit, and to judge from Mr. Hincks's figure, the less diameter of the zoœcial tubes, and their less entire immersion or connation. In *Stomatopora fasciculata*, moreover, the zoarium is described as having a dense and smooth surface and a dark brown colour.

Mr. Couch's description of *Tubulipora deflexa* is far too incomplete to afford any assistance towards its determination, and his figure is still less reliable. All he says is that the zoarium is erect, cylindrical, with waved tubes projecting from all parts. Mr. Hincks, however, states, with respect to his *Stomatopora deflexa*, that the "zoarium is in great part adherent; with linear branches expanding very slightly upwards, the extremities free, erect, subclavate. The zoœcia slender, disposed in pairs along the creeping portion, and semialternate or alternate, the oral extremity free, bent upwards, and projecting considerably." To this it may be added that Mr. Hincks rejects Professor Smitt's *Entalophora deflexa* as a synonym of his *Stomatopora deflexa*. So that on the whole it seems extremely doubtful what name should be assigned to the form here described, with respect to which all that appears to me to be certain is that the specimens (mere fragments) in the Challenger collection are identical with the form

described by Professor Smitt as *Entalopora deflexa.* It is scarcely possible that Mr. Hincks's *Stomatopora* should be the same, but to indicate the possibility that it may be a recent variety, I have retained the specific appelation for a decided *Pustulopora*, for which otherwise the name "*fasicularis*" would have been very appropriate.

(4) *Pustulopora regularis*, Macgillivray (Pl. IV. fig. 2).

Pustulopera (*sic*) *regularis*, Proc. Roy. Soc. Vict., vol. xix., 1882, p. 292, pl. i. fig. 3.
? *Pustulopora subverticillata*, Busk, Crag Polyzoa, p. 108, pl. xviii. fig. 1*d*.

Character.—Zoarium branched, branches of uniform thickness (about 1 to 2 mm.), furcate and ending in a short fork. Entire surface studded with the exserted extremities of the immersed zoœcia, disposed quincuncially or in nearly regular subspiral series, and about eight in the width of the zoarium. Orifice 0·12 to 0·15 mm. in diameter. Surface of zoœcia punctate, except the peristomal production which is clear, vitreous, shining and ringed. Oœcia ?

Habitat.—Station 162, off East Moncœur Island, Bass Strait, 38 fathoms, sand and shells.

[Port Philip Heads, Macgilliv.]

Probably, as suggested by Mr Macgillivray, allied to *Entalophora subregularis*, d'Orbigny.

Subdivision B. ADNATA seu DECUMBENTIA.

Family III. Tubuliporidæ, Busk.

Tubuliporidæ, Bk., Crag Polyzoa; Brit. Mus. Cat. pt. iii. p. 23.
Tubuliporidæ (pars), Johnst., Blainville, Milne-Edwards ("*Tubulipores*"), Smitt, Alder, Gray, Hincks, Vine, &c.
Sparsidæ (pars) d'Orbigny.

Character.—Zoarium entirely adnate, partially erect from an expanded base, in shape linear, reniform, flabelliform, or claviform; simple or divided into branching lobes. Zoœcia distinct, more or less free and much elongated; irregularly disposed or ranged in more or less regular series, diverging from a mesial line. Oœcia formed by an inflation of the branch.

The Family here contains:—

1. *Alecto*, Lamx.
   (1) *Alecto granulata*, M.-Edw.
2. *Tubulipora*, Lamk.
   (1) *Tubulipora flabellaris*, Fab. (Pl. V. fig. 1).
   (2) *Tubulipora fimbria*, Lk. (Pl. V. fig. 2).

1. *Alecto*, Lamouroux.

Alecto, Lamx., 1821; Blainville, Johnston, M.-Edw., Busk., Michelin, Gray, Norman, Heller, &c.
Tubulipora (pars), Lamk., Smitt.
Stomatopora, Bronn, d'Orb., Hincks (pars), &c.
Aulopora (pars), Goldfuss, Reuss.
Diastopora, (pars), Smitt.
? *Proboscina* (pars), Audouin, d'Orb., Smitt (subgenus).

Character.—Zoarium closely adnate throughout; simple or branched; linear or ligulate. Zoœcia uniserial, or disposed in distant, more or less regular, transverse series of two to four.

(1) *Alecto granulata*, Milne-Edwards.

Alecto granulata, M.-Edw., Réch. sur les Crisies, p. 13, pl. xvi. fig. 3, 3*a*; Johnston (pars), Busk, Brit. Mus. Cat., pt. iii. p. 24, pl. xxxii. fig. 1; Joliet.
? *Alecto parasitica*, Heller, Manzoni.
Stomatopora granulata, d'Orb., *loc. cit.*, p. 836, pl. 628, figs. 5–8; Hincks, Brit. Mar. Polyz., p. 425, pl. lvii. figs. 1, 2.

Character.—Zoarium linear, branched, the branches often anastomosing. Zoœcia uniserial, decumbent, with the oral extremities raised, subventricose below; surface granular or coarsely ringed.

Habitat.—Off Inaccessible Island, Tristan da Cunha, 60 to 90 fathoms (on dead shell). [British and Irish coasts; Norway and Sweden, Roscoff, &c.]

2. *Tubulipora*, Busk.

Tubulipora, Bk., Engl. Cyclop., art. Polyzoa, col. xv.; Crag Polyzoa, p. 110; Lamouroux, Hagenow, &c., Bk., Brit. Mus. Cat., pt. iii. p. 24.
Tubulipora (pars), Lamarck, Blainville, M.-Edwards, Johnston, Lonsdale, Michelin, Reuss, d'Orbigny, Gray, Smitt (1867), Hincks, &c.
Ceriopora (pars), Hagenow.
Phalangella sp., Gray, Smitt (subgenus).
Proboscina sp., d'Orbigny.

Characters.—Zoarium springing from a minute subglobular or discoid cell, and expanding as it grows, into an irregularly lobate, or entire, reniform or fan-shaped, adnate growth, from which spring the elongated, cylindrical, tubular zoœcia, free or partially connate and ascending; disposed more or less regularly in series diverging from a mesial line or irregularly.

(1) *Tubulipora flabellaris*, Fabricius (sp.) (Pl. V. fig. 1).

Tubipora flabellaris, Fab., Faun. Grœnl., p. 430, 1780.
Tubulipora flabellaris, Manzoni, Hincks, Brit. Mar. Polyz., vol. i. p. 446, pl. lxiv. figs. 1–3.
Tubulipora (subgenus *Phalangella*) *flabellaris*, Smitt, 1866; Kritisk Förteckn., pp. 401, 455, pl. ix. figs. 6, 8.
Tubulipora phalangea, Couch, Corn. Fauna, vol. iii. p. 106, pl. xix. fig. 7; Johnston, Busk, Crag Polyzoa, p. 111, pl. xviii. fig. 6; Hincks, Devon. Cat., Ann. and Mag. Nat. Hist., ser. 3, vol. ix. p. 308; Busk, Brit. Mus. Cat., pt. iii. p. 25, pl. xxiii.; Waters, &c.
Tubulipora verrucaria, M.-Edw. (pars), Réch. sur les Tubulipores, p. 3, pl. xii. fig. 1; Heller.
Phalangella phalangea, Gray.

Character.—Zoarium wholly adnate, suborbicular or reniform, or obsoletely lobate; tubular cells long, slender, 0·15 mm. in diameter, disposed in more or less regular, uniserial rows radiating from a mesial line. Walls of free portion of zoœcia ringed, not punctate. Basal expansion thickly punctate.

Habitat.—Station 315, lat. 51° 40′ S., long. 57° 50′ W., 12 fathoms, sand and gravel.

[British and Irish Seas; Arctic Sea; coast of Norway; South Labrador; Adriatic, Bay of Naples.]

Professor Smitt and Mr. Hincks appear to be so convinced that this is the form intended by Fabricius that I have thought it better to adhere to their determination and to adopt his appellation instead of Mr. Couch's.

One peculiarity as distinguishing this form from the very closely allied *Tubulipora fimbria*, Lamk., consists in the absence, so far as I have observed, of punctation of the walls of the tubular or free portion of the zoœcia, which in the latter species are sparsely punctate up to the border of the orifice, also the punctation of the basal expansion in *Tubulipora fimbria* is rather more sparse, and the spots or pores larger.

(2) *Tubulipora fimbria*, Lamarck (Pl. V. fig. 2).

? *Tubipora serteus*, Fab.
Tubulipora fimbria, Lamk., Hist. Anim. sans Vert., ed. 1, vol. ii. p. 163, ed. 2, vol. ii. p. 243; Smitt, (subgenus *Phalangella*), *loc. cit.*, p. 401, 452, pl. ix. fig. 5; Hincks, Brit. Mar. Polyz., p. 448, pl. lx. fig. 3.
Tubulipora fimbriata, M.-Edw., *loc. cit.*, p. 10, pl. xiv. fig. 2; Michelin, Iconog., p. 321, pl. lxxvii. fig. 7.
Tubulipora flabellaris, Johnst., p. 274, pl. xlvi. figs. 5, 6; Landsb., Pop. Hist. Brit. Zooph., p. 274, pl. xv. fig. 50; Busk, Crag Polyzoa, p. 111, pl. xviii. fig. 3, pl. xx. fig. 9; Brit. Mus. Cat., pt. iii. p. 25, pls. xxiv., xxv.; Hincks, Ann. and Mag. Nat. Hist., ser. 4, vol. xix. p. 109; Haswell, Joliet.

Character.—Zoarium adnate, flabelliform, often recurved on the sides. Zoœcia decumbent, irregularly disposed or very obscurely serial. Surface of basal expansion and tubes punctate, often transversely rugose. Zoœcia about 0·15 to 0·17 mm.

Habitat.—Station 315, lat. 51° 40′ S., long. 57° 50′ W., 12 fathoms, sand and gravel.

[Northern coast of Britain; Shetland; Ireland; Greenland, Fabricius; Davis Strait,

100 fathoms; Gulf of St. Lawrence; Spitzbergen; West of Nova Zembla, lat. 72° 30′ N., long. 52° 45′ E., 5 to 20 fathoms, Stuxberg and Théel; Roscoff, Joliet; Port Jackson, Haswell.]

Distinguished from the preceding species, as above observed, by the tubular portions of the zoœcia being punctate up to the border of the orifice, and their rather larger size. There can, I now think, be no doubt as to the distinctness of the two species.

Family IV. DIASTOPORIDÆ, Busk.

Diastoporidæ (pars), Bk., Crag Polyzoa, p. 113, Smitt.
Tubuliporidæ (pars), Hincks, &c.

Character.—Zoarium crustaceous or foliaceous, discoid or of indefinite outline; adnate and sessile, or pedunculate and erect; no interstitial cancelli.

The Family here contains:—

1. *Diastopora*, Johnston.
   (1) *Diastopora patina.*

1. *Diastopora*, Johnston.

"*Diastopores simples*," M.-Edwards, Rech. sur les Crisies, p. 39.
Diastopora, Johnst., Bk., Crag Polyzoa, p. 113; Brit. Mus. Cat., pt. iii., p. 28; Hincks, Brit. Mar. Polyz., p. 457.
Diastopora (pars), Lamx., M.-Edwards, Blainville, Reuss, Hagenow, Michelin, d'Orbigny, Smitt.
Tubulipora sp., Johnst., Auctt.
Berenicea (pars), Lamx., d'Orbigny.
Patinella, Gray, Hincks, Zooph. S. Devon, Ann. and Mag. Nat. Hist., ser. 3, vol. ix. p. 468.

Character.—Zoarium adnate, discoid or flabelliform, centric or excentric; outline lobed or entire. Zoœcia towards the centre wholly immersed, usually sub-erect and partially free towards the periphery; orifice orbicular or elliptical; horizontal or oblique.

(1) *Diastopora patina*, Lamarck (sp.).

Tubulipora patina, Lamk., Johnst., Gosse, Mar. Zool., pt. iii., p. 8, fig. 1 (*nec* Milne-Edwards); Joliet.
? *Patinella verrucaria*, Gray.
Patinella patina, Hincks, Zooph. S. Devon, Ann. and Mag. Nat. Hist., ser. 3, vol. ix. p. 468.
Diastopora patina, Smitt., Busk, Brit. Mus. Cat., pt. iii., p. 28, pl. xxix. figs. 1, 2, pl. xxx. fig. 1; Hincks, Brit. Mar. Polyz., vol. i. p. 458, pl. lxvi. figs. 1–6; Waters.
? *Discosparsa marginata* (pars), d'Orbigny.
Discosparsa patina, Heller, Marion.

Character.—Zoarium when mature, discoid, circular, cupped, and bordered by a thin expansion. Central zoœcia immersed and usually occluded; marginal ones erect and

open, usually disposed in irregular wavy lines radiating from the centre. (Sometimes gemmiparous, Hincks).

Habitat.—Off Nightingale Island, Tristan da Cunha, 100 to 150 fathoms.

[British and Irish Coasts, northern and southern; North Sea, Arctic Ocean, 5 to 10 fathoms, on Fucus, Flustra, &c., and on shells and coral from 50 to 100 fathoms, Smitt; coast of Norway, Lovén; Shetland, Barlee, 170 fathoms; Adriatic, Heller; South Labrador; Marseilles, Marion; Roscoff, Joliet.]

Family V. LICHENOPORIDÆ.

Lichenoporidæ, Smitt, Hincks, &c.
Discoporadæ, Bk., Engl. Cyclop.
Caveidæ (pars), d'Orbigny.
Tubigeridæ (pars), d'Orbigny.
Discoporellidæ, Bk., Brit. Mus. Cat., pt. iii. p. 30, 1875.

Character.—Zoarium discoid, simple or confluent; adnate or substipitate, interzoœcial spaces cancellate (cancelli sometimes obsolete). Zoœcia erect or suberect, disposed more or less regularly in series diverging from an open central area.

The Family here contains:—

1. *Lichenopora.*

(1) *Lichenopora fimbriata*, Bk.
(2) *Lichenopora hispida*, Flem.

1. *Lichenopora*, Defrance.

Madrepora (pars), Fabr., Esper.
Lichenopora, Defrance (1823), Blainville, Michelin, Smitt (1878), Hincks, Brit. Mar. Polyz., p. 471.
Discoporella, Gray, Brit. Mar. Rad.; Busk, Crag Polyzoa, and Brit. Mus. Cat., pt. iii. p. 30; Smitt, Kritisk Förteckn., p. 405 (1865).
Discopora (pars), Flem. (*non* Lamk.), Busk, Engl. Cyclop. Polyz.
Tubulipora (pars), Johnst., M.-Edw., &c.
Defrancia (pars), *Actinopora*, *Discocavea*, *Unicavea*, &c., d'Orb.
Heteroporella sp., Hincks.

Character.—Zoarium sessile, usually closely adnate, with a thin calcareous border; discoid, raised in the centre (hemispherical, conical, or subconical). Zoœcia partly free, disposed irregularly or in lines radiating from the centre. Mouth acuminate or toothed.

(1) *Lichenopora fimbriata*, Busk.

Discoporella fimbriata, Bk., Brit. Mus. Cat., pt. iii. p. 32, pl. xxvii.

Character.—Zoarium subconical or hemispherical; zoœcia indistinctly serial, distant; interstitial cancelli or pores small, circular, often more or less obsolete; orifice somewhat expanding; peristome fimbriate, with a variable number of pointed teeth.

Habitat.—Off Nightingale Island, Tristan da Cunha, 100 to 150 fathoms.

[Chonos Archipelago, 13 fathoms; Tierra del Fuego, Cape Horn, 40 fathoms; Chiloe, 96 fathoms, Darwin; Tasmania, Mr. Smith.]

(2) *Lichenopora hispida*, Fleming (sp.).

Discopora hispida, Fleming, Blainville, Couch.
Tubulipora hispida, Johnst.
Discoporella hispida, Gray; Busk, Crag Polyzoa, p. 115, pl. xviii. fig. 5; Brit. Mus. Cat., pt. iii. p. 30, pl. xxx. fig. 3; Smitt, Sars, Alder, &c.
Heteroporella radiata, Bk., Crag Polyzoa, p. 127, pl. xix. fig. 2.
Heteroporella hispida, Hincks, Ann. and Mag. Nat. Hist., ser. 3, vol. ix. p. 469.
Lichenopora hispida, Hincks, Brit. Mar. Polyz., p. 473, pl. lxviii. figs. 1–8.

Charcter.—Zoarium suborbicular, convex, with or without a narrow marginal lamina; surface uniformly covered with circular openings level with the surface, of tolerably uniform size; towards the border some of the orifices raised, subtubular, and bi- or tridenticulate, disposed in obscure irregular series.

Habitat.—Stations 135 to 135G, Tristan da Cunha, 100 to 1100 fathoms.

[British Coasts, north and south; Northern Seas, Greenland, Labrador, &c. (fossil, Coral Crag; Post Pliocene, Canada).]

Family VI. Frondiporidæ, Smitt.

Fasiculinea (pars), d'Orbigny, Smitt, 1866.
Fascigeridæ (pars), d'Orbigny.
Frondiporidæ, Smitt, Kritisk Förteckn., pp. 407, 408 (1866); Busk, Brit. Mus. Cat., pt. iii. p. 37.
Cerioporidæ (pars), Busk, Crag Polyzoa, p. 118.
Cerioporinæ (pars), Hagenow.

Character.—Zoarium massive, stipitate, simple or lobate, or ramose. Zoœcia connate throughout, aggregated into fasciculi; lumen of tubes angular; walls finely porous; sides of lobes or fasciculi faintly striated or subporcellanous; no intermediate pores or cancelli.

The Family here contains:—

1. *Fasciculipora*, d'Orb.

(1) *Fasciculipora ramosa*, d'Orb.

2. *Supercytis*, d'Orb.

(1) *Supercytis digitata*, d'Orb. (Pl. V. fig. 3).
(2) *Supercytis tubigera*, n. sp. (Pl. V. fig. 4).

1. *Fasciculipora*, d'Orb.

Fasciculipora, d'Orb. (1839), Busk, Brit. Mus. Cat., pt. iii. p. 37 (pars).
Frondipora, Michelin (pars); Hagenow.
Corymbopora (pars), Michelin.
Corymbosa, sp., d'Orbigny.
Fungella, Hagenow, Bk., Crag Polyzoa, p. 118.

Character.—Zoarium stipitate; capitulum lobate. Zoœcia opening only at the ends of the fasciculi.

(1) *Fasciculipora ramosa*, d'Orbigny.

Fasciculipora ramosa, d'Orb., Voy. Amér. Mérid., Polypiers, p. 20, pl. ix. figs. 22–24.
? *Frondipora ramosa*, Hagenow.
Corymbosa ramosa, d'Orb., Cours Elém. de Pal., tom. ii. p. 109, 1851.
? *Fungella prolifer*, Hagenow, Maast. Kreid., p. 37, pl. iii. figs. 6, 7 (?).

Character.—Zoarium fungiform; capitulum composed of numerous obtuse, rounded lobes (usually in pairs); each lobe constituted of a thick fasciculus of tubular cells of large calibre and very thin walls, with a few intermediate tubes of less diameter interspersed; outer surface smooth, dotted obscurely, showing the outline of the elongated zoœcia, or thickened and procellanous.

Habitat.—Off Inaccessible and Nightingale Islands, Tristan da Cunha, 60 to 150 fathoms.

[South Patagonia, 48 fathoms, Darwin, d'Orbigny.]

Fasciculipora ramosa bears a close resemblance to *Fungella multifida*, mihi, of the Crag (pl. xvii. fig. 4), but in that species, which probably corresponds with *Frondipora marsilli* of Michelin (Iconog., p. 68, pl. xiv. fig. 4). The whole growth appears more squat or depressed, and the lobes shorter and not in pairs, whilst the outer surface towards the base is marked with hexagonal areolæ, an appearance not seen in *Fasciculipora ramosa*. Otherwise the two forms appear to be closely allied.

2. *Supercytis*, d'Orbigny.

Supercytis, d'Orbigny, Palæont. Franç., p. 1060; Waters, Quart. Journ. Geol. Soc., vol. xl., 1884, p. 692.
Fasciculipora (pars), d'Orbigny; Busk, Brit. Mus. Cat., pt. iii. p. 37.

Character.—Zoarium stipitate; capitulum expanded, flat or cupped, with numerous furcate or trifid fasciculi projecting round the border. Fasciculi compressed, constituted of coalesced, almost completely immersed zoœcia of varying lengths, all of which open on the upper flattened side of the fasciculus or at the extremity. Dorsal surface rounded, even, longitudinally striated and minutely punctate. Oœcia (when present) hemispherical, at the base of the fasciculi, and usually on the upper surface.

It is not easy to assign its proper family place to this peculiar type, but on the whole it would perhaps be more at home among the Fasciculinæ or Frondiporidæ, than elsewhere, the main difference between it and the other members of the group consisting in the openings of the zoœcia not being altogether terminal but partly on the upper side of the lobes or lateral fasciculi, or more rarely on the central area of the capitulum, which in one of the forms here described, in the perfect and perhaps more or less immature state, is covered with an even, calcareous, minutely punctate lamina, marked out into very regular hexagonal areolæ, from some of which, towards the border, may be seen the slightly projecting orifices of zoœcia. In the second species the hexagonal areolation is apparently wanting, and in this form a few long tubular zoœcia project at the base of some of the fasciculate lobes.

In the British Museum Catalogue I have described and figured, under the name of *Fasciculipora digitata*, a species, which as pointed out by Mr. Waters (*loc. cit.*, p. 692), is in all probability identical with M. d'Orbigny's *Supercytis digitata*, but in that specimen, which was a good deal worn, the hexagonally areolated, calcareous lamina of the central area is absent, and nothing is seen but the open orifices of what might be taken for the interstitial cancelli characteristic of the Lichenoporidan group. There can, however, I think, be no doubt that they represent the orifices of stunted or undeveloped zoœcia, because, firstly, towards the base of the digitiform lateral fasciculi many of the areolæ are actually developed into short zoœcial tubes; and secondly, in none can be traced a vestige of the internal ciliary processes which are seen almost universally in true interstitial cancelli. Besides these marginal stunted zoœcia, there may be seen in all parts of the central area similar projecting orifices, which are described by Mr. Waters as the ends of central zoœcia slightly exserted, and which, as he remarks, give this portion the aspect of a *Diastopora*, such as *Diastopora sarniensis*.

(1) *Supercytis digitata*, d'Orbigny (Pl. V. fig. 3).

> *Supercytis digitata*, d'Orb., Palæont. Franç., p. 1061, pl. dccxcviii. figs. 6–9; Waters, *loc. cit.*, p. 692, pl. xxxi. figs. 22, 26, 27.
>
> *Fasciculipora digitata*, Bk., *loc. cit.*, p. 37, pl. xxxiii. fig. 1.

Character.—Zoarium oblong, 0·12 × 0·8 mm.; the stipitate capitulum flattened above, presents a large central area covered with a hexagonally areolated lamina, and from the sides project twelve digitate, forked, or sometimes trifid compressed lobes, composed of longer or shorter tubular zoœcia, about 0·2 mm. in diameter, almost completely immersed or sometimes slightly projecting, and opening throughout the whole length of the lobe on its upper flattened aspect, and some from the areolæ of the central area. Dorsal aspect of the lobes rounded, even, longitudinally striated and minutely punctate. Oœcia ?

Habitat.—Station 167, lat. 39° 32′ S., long. 171° 48′ E., 150 fathoms, blue mud.

[Cape Capricorn, Australia, H.M.S. "Rattlesnake." Fossil, Cretaceous, Meudon, &c., d'Orbigny; South Australia, Waters.]

(2) *Supercytis tubigera*, n, sp. (?) (Pl. V. fig. 4).

Character.—Zoarium stipitate, capitulate; capitulum irregular or inequilateral; central area small, not areolated, but covered with a thickish calcareous lamina, with concentric rugæ, giving it a conchoidal aspect; ten or twelve marginal fasciculate or digitate bi- or trifurcate compressed processes, in which the zoœcia are disposed more or less regularly in series of connate tubes, opening either at the extremity of the fasciculus or on its upper flattened aspect; at the base of some of the fasciculi a few much elongated tubular zoœcia arise nearly vertically, with punctate walls, and about 0·25 mm. in diameter. Dorsal surface of fasciculi and capitulum striated and minutely punctate. Oœcia in the form of hemispherical projections at the base of the lateral fasciculi and usually on the upper aspect.

Habitat.—Station 151, off Heard Island, 75 fathoms, volcanic mud.

As the collection affords only a single specimen, which conveys the impression of a somewhat distorted growth, it may, perhaps, be merely a variety of the preceding. But the absence of areolation of the central area of the capitulum and the presence of the much elongated tubular zoœcia, together with the occurrence of the hemispherical oœcia, appeared to me to justify its being considered specifically distinct.

Sub-Order III. CTENOSTOMATA, Busk.

Ctenostomata, Busk, Hincks, Smitt, Auctt.
Halcyonellea and *Vesicularina*, Johnst.

Character.—Zoœcial orifice simply circular, bilabiate (?) or quadrangular; retractile; border contractile, furnished with a setose or membranous fringe or velum. Zoarium corneous or membranaceous, or carnose; never calcified. No marsupial or appendicular organs.

Division I.—HALCYONELLEA.

Halcyonellea, Ehrenberg, Hincks.
Polyzoa carnosa, Gray.
Alcyonidulæ, Johnst.
Halcyonellæ, Smitt.

Character.—Zoarium membranous or carnose, or semigelatinous, developed by continuous gemmation of the zoœcia from each other.

This division, embracing in Mr. Hincks' classification the genera

Alcyonidium,
Flustrella,
Arachnidium,

is represented in the Challenger collection by a single species referable to *Alcyonidium*.

Family I. Alcyonidulæ.

Alcyonidulæ, Couch.
Halcyonellex, Smitt.
Alcyonidiidæ, Hincks.

Character.—Zoœcia more or less closely united, immersed in an expanded and adherent gelatinous crust, or forming an erect, cylindrical or compressed zoarium; orifice closed by the invagination of the tentacular sheath.

The Family here contains:—

1. *Alcyonidium*, Lamouroux.

(1) *Alcyonidium flustroides*, n. sp. (Pl. X. figs. 13, 14).

1. *Alcyonidium.*

Alcyonidium, Lamx., Johnst., Couch, Busk, Engl. Cyclop., art. Polyz.; Hincks, &c.
Alcyonium (pars), Linné, Pallas, Müller, Fleming, &c.
Halodactylus, Farre, v. Beneden.
Cycloum and *Sarchochitum*, Hassall.

Character.—Zoœcia immersed or subimmersed. Orifice usually papillæform, more or less exsertile. Zoarium erect and lobate or crustaceous or repent.

(1) *Alcyonidium flustroides*, n. sp. (Pl. X. figs. 13, 14).

Character.—Zoarium erect and foliaceous, much branched, extending to 4 or 5 inches; bilaminate, compressed and flustroid. Zoœcia polygonal, arranged in irregular longitudinal series, the septa between which are raised and strongly marked. The substance of the walls semigelatinous, irregularly dotted with small black granules. Orifice minute, papillæform, superior. Polypide with about sixteen tentacles. Ova scattered, usually singly, in the zoœcia. Width of branches about 4 mm.; zoœcia irregular in size, from about 0·8 × 0·4 mm. to 1·6 × 0·6 mm.

Habitat.—Station 142, lat. 35° 4′ S., long. 18° 37′ E., 150 fathoms, green sand.

This species forms straggling tufts of loosely entwined and sometimes anastomosing branches, which are quite soft and flexible in the upper part, though the stem and lower branches become hard and firm near the base. Sometimes the branches embrace and adhere firmly to some foreign substance, such as worm tubes, &c. The structure is at first sight very obscure, as the substance is very thick and opaque; immersion for a short time in acid, however, renders it much more transparent and enables the nature of the zoœcia to be seen. Many of these contain polypides alone, others polypides and ova together, and others again either "brown bodies" or scattered ova only. The orifices are very small and often quite obscure. The walls seem to be partly membranous and partly of a semigelatinous nature, irregularly dotted with small black granules which are possibly argillaceous. In the form of the cell and the raised septa this species resembles *Alcyonidium mytili*, as described by Mr. Hincks,[1] but entirely differs from that form in its erect bilaminate mode of growth.

[1] Brit. Mar. Polyz., p. 498, pl. lxx. figs. 2, 3.

Division II.—VESICULARINA.

Vesicularina (pars), Johnst.
Stolonifera, Ehlers, Hincks.
Les centrifuginées radicellés (pars), d'Orb.
Vesiculariea, Smitt.

Character.—Zoarium corneous, developed by the continuous segmentation of a branching stem or stolon, having a transverse diaphragm at each node. Zoœcia budding directly from the internodes and not from each other.

Family II. Vesicularidæ.

Vesiculariadæ, Johnst., Alder, &c.
Vesiculariidæ and *Valkeriidæ*, Hincks.
Vesiculariex, Smitt.

Character.—Zoarium erect, free and ramose or radicate, repent or stoloniferous. Zoœcia deciduous or readily detached, leaving a circular area filled in by a perforated diaphragm. Wall entire all round, without any membranous area.

The Family here contains the following genera :—

1. *Amathia*, Lamouroux.

(1) *Amathia lendigera*, Linn.
(2) *Amathia distans*, n. sp. (Pl. VII. fig. 1).
(3) *Amathia brasiliensis*, n. sp. (Pl. VII. fig. 2).
(4) *Amathia spiralis*, Lamx. (Pl. VI. fig. 2).
(5) *Amathia tortuosa*, Woods (Pl. VI. fig. 1).
(6) *Amathia connexa*, n. sp. (Pl. VI. fig. 3).
(7) *Amathia semispiralis*, Kirchenpauer (Pl. VIII. fig. 3).

2. *Vesicularia*, J. V. Thompson.

(1) *Vesicularia papuensis*, n. sp. (Pl. VIII. fig. 1).
(2) *Vesicularia trichotoma*, n. sp. (Pl. VIII. fig. 4).

3. *Farrella*, Ehrenburg.

(1) *Farrella brasiliensis*, n. sp. (Pl. VII. fig. 3).

1. *Amathia*, Lamouroux.

Sertularia (pars), Linn.
Amathia, Lamx., d'Orbigny (pars); Kraus, Heller, Hincks, &c.
Serialaria, Lamk., Fleming, Johnst., Blainville, Kirchenpauer, d'Orbigny (pars), Busk, Engl. Cyclop., art. Polyz.; Joliet, Barrois, &c.
Valkeria (pars), Dalzell.

Character.—Zoarium radicate, erect or creeping, with free dichotomous branches. Zoœcia cylindrical or subovoid, with a broad adherent base, and more or less connate laterally; arranged alternately in a double series, disposed spirally, entirely or partially surrounding the internodes, or in a straight line parallel with the axis, or in short distant groups at the upper ends of the internodes.

(1) *Amathia lendigera*, Linné (sp.).

"Nit Coralline," Ellis.
Sertularia lendigera, Linné, Pallas, Ellis and Sol., Lister.
La Sertolara lendinosa, Cavolini.
Amathia lendigera, Lamx., Pol. flex., p. 159; Heller, Hincks, Brit. Mar. Polyz., p. 516, pl. lxxiv. figs. 7–10, &c.
Serialaria lendigera, Lamk, Auctt.
Valkeria lendigera, Dalyell.

Character.—Zoarium much branched, tangled, filamentous; branches dichotomous, about 0·5 × 0·15 mm. Zoœcia subcylindrical, ovate, subcompressed, tapering gradually in a long neck, disposed obliquely in series of four to five pairs close below each joint or bifurcation, and gradually diminishing in length from below upwards. Cells subdistinct, and scarcely connate.

Habitat.—Station 36, off Bermuda, 30 fathoms, coral.

[British and European Seas, *ubique.*]

(2) *Amathia distans*, n. sp. (Pl. VII. fig. 1).

Character.—Zoarium very slender and delicate, straggling, filamentous, very regularly dichotomous. Internodes long, straight, rigid, thick-walled, about 0·15 mm. in diameter, of pretty uniform length, and each completely encircled with a spiral coil, occupying usually not more than the upper half of the internode, the lower portion of which is left bare. Zoœcia ovoid or oblong, about 0·4 or 0·5 mm. by 0·1 to 0·15 mm., distinct or not closely connate, with a short conical neck.

Habitat.—Off Bahia, 10 to 20 fathoms, mud.

This form is at once recognisable by its delicate filamentous growth, and the great distance between the spiral coils, giving it somewhat the aspect of *Amathia lendigera* Another character is the comparative shortness and distinctness of the zoœcia.

(3) *Amathia brasiliensis*, n. sp. (Pl. VII. fig. 2).

Character.—Zoarium several inches high (?), irregularly branched; branches frequently terminating in two long jointed filaments, which occasionally throw out one or two isolated zoœcia or stunted branches at the nodes. The branches sometimes also commence with two or three barren internodes. Stems about 0·3 mm. in diameter, wall white and delicate. Zoœcia disposed in a more or less complete spiral, which in the younger internodes occupies only the upper part, but in the older nearly their entire length; very distinct, subcylindrical, tapering from the base upwards, about 0·6 × 0·1 mm.; neck long and slender.

Habitat.—Off Bahia, 10 to 20 fathoms, mud.

The striking peculiarity of this form is the tendency of the branches to terminate in two long jointed tags (terminals), usually barren, but sometimes giving off one or two scattered isolated cells in the manner of some of the Vesiculariæ, &c. The comparative distinctness of the zoœcia in the spiral series shows a tendency in the same direction.

(4) *Amathia spiralis*, Lamouroux (Pl. VI. fig. 2).

Amathia spiralis, Lamx., Polyp. Flex., p. 161, pl. iv. fig. 2.; Expos., p. 10, pl. lxv. figs. 16–17; Encyclop., p. 44.
Serialaria convoluta, Lamarck, Schweigger.
? *Serialaria spiralis*, Woods, Proc. Roy. Soc. N.S.W., vol. xi. p. 84, 1877.
? *Amathia bicornis*, Woods, Trans. Roy. Soc. Vict., vol. xvi. p. 102, 1880.

Character.—Zoarium very thick, branched subdichotomously or irregularly, several inches high. Zoœcia subcylindrical, of uniform diameter, very closely connate, 1·0 mm. long, by 0·2 mm. in diameter (at base); the exserted neck thick and very strongly wrinkled; transversely disposed in an apparently continuous spiral from one internode to another, though in reality probably discontinuous at each internode.

Habitat.—Station 161, off entrance to Port Philip, 33 fathoms, sand. Station 162, off East Moncœur Island, Bass Strait, 38 fathoms, sand and shells. Station 163A, off Twofold Bay, 150 fathoms, green mud.

[Bass Strait and Australia, *ubique* (?), Lamx., &c.]

(5) *Amathia tortuosa*, Woods, (Pl. VI. fig. 1).

? *Amathia tortuosa*, Woods, Proc. Roy. Soc. Vict., vol. xvi. p. 89, fig. 6.

Character.—Zoarium 3, 4 or 5 inches high, in thick tufts, when spread out divaricate, with long subalternate branches; rooted by radical fibres. Dull olive green colour. Stem 0·5 to 0·6 mm. in diameter. Zoœcia slender, about 1 mm. × 0·15 to 0·2 mm., disposed spirally round the internodes, but not always forming quite one turn.

Habitat.—Station 163A, off Twofold Bay, 150 fathoms, green mud.
[Australia, J. T. Woods.]

It appears to me very doubtful whether this is really the form so named by Mr Woods, who may probably not have distinguished it from the next species, which in its general habit seems to resemble the figure of his *Amathia tortuosa* more than the present. However, I am led to suppose that he had this one in view from his remark respecting the great length of the cells, which in my *Amathia connexa* are rather short. What Mr. Woods intends by "a crescentic mouth, without setæ or spines," I do not clearly understand; and it should moreover be remarked, that in his figure of *Amathia tortuosa* the cells are not represented by any means as unusually long.

(6) *Amathia connexa*, n. sp. (Pl. VI. fig. 3).

Character.—Zoarium 3 to 4 inches high, very irregularly branched, straggling, forming dense tufts. Stem and branches from 0·5 to 0·6 mm. in diameter, transparent as glass, each internode encircled with a spiral series of zoœcia not extending its entire length, but leaving a space at each end clear. Branches here and there connected by transverse barren tubes. Zoœcia oblong, 0·5 × 0·13 mm., abruptly rounded (the neck projecting about 0·2 mm.), connivent, very delicate walls, so that the outlines towards the summits are very indistinct.

Habitat.—Station 186, off Cape York, 8 fathoms, coral mud.

The main characteristics of this form consist in—

1. The comparatively large diameter of the segmented stems and the beautiful glassy transparency of their walls, upon which the encircling series of zoœcia appear to stand out in strong relief, so as at first sight to seem as if they were disposed on one side only of the segment; but examination shows that in reality they form nearly or wholly complete circles round the stem.

Fig. 1

Fig 2.

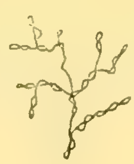

Fig. 1.—*Amathia connexa.*
Fig. 2.—*Amathia tortuosa*, Woods.

2. A second very striking feature, that I have not noticed in any other species of *Amathia*, is the occasional connection of the branches by transverse, barren, segmented tubes, resembling a similar arrangement in some of the Cheilostomata. As observed in the description of the preceding species, the general habit of *Amathia connexa* closely resembles that of Mr. Woods' *Amathia tortuosa*, as shown in his figure, which is copied in the accompanying woodcut. But that *Amathia connexa* should be the species intended by him under the name *tortuosa* is contradicted, as has been remarked, by the comparative shortness of the zoœcia.

(7) *Amathia semispiralis*, Kirchenpauer (sp.) (Pl. VIII. fig. 3).

Serialaria semispiralis, Kirchenpauer, Cat. Mus. Godefroy, vol. iv. p. xxxiv., 1869.

Character.—Zoarium filamentous, dichotomous; stem brownish, about 0·3 mm. in diameter. Zoœcia disposed in short series, composed of four to eight pairs of cells; series distant, placed obliquely, three or four in each internode; zoœcia slender, cylindrical or somewhat quadrangular in form, about 0·6 to 0·7 × 0·15 mm., obtuse and strongly wrinkled transversely at the closed end; neck very short, and setæ short.

Habitat.—Station 188, lat. 9° 59′ S., long. 139° 42′ E., 28 fathoms, green mud. [Samoa, Kirchenpauer.]

It may be doubtful whether this form is really that intended by Kirchenpauer, who (*loc. cit.*) describes the zoarium as "dichotomously branched. The cells dispersed in biserial groups, at certain distances apart, and spirally round the stem; each spiral, however, extending only about one-half round the axis. From *Serialaria semiconvoluta*, Lamk., it differs in the character that in that species the tubular cells form much longer rows, whilst it also has an entirely different habit." How M. Kirchenpauer can bring it at all in comparison with the *Serialaria continhii*, which in habit more resembles a Mimosella, is more than I can imagine. No two things would appear to be more distinct.

2. *Vesicularia*, Thompson.

Vesicularia, J. V. Thompson (pars); Farre, Johnst. Busk, Engl. Cyclop.; Hincks, Brit. Mar. Polyz., p. 512, &c.
Sertularia (pars), Linné, Pallas, &c.
Laomedea (pars), Lamx., Blainville.
Valkeria (pars), Fleming.

Character.—Zoarium erect, radicate, or rooted by a fibrous base. Zoœcia distinct, usually distant, disposed in a single row or alternately in two rows on one face only of the stems. (Polypides with a gizzard, Hincks).

(1) *Vesicularia papuensis*, n. sp. (Pl. VIII. fig. 1).

Character.—Zoarium about $\frac{3}{4}$ inch high, very delicate, branching dichotomously in one plane, at an acute angle, rooted by short radical fibres. Branches composed of three or four internodes, about 0·15 mm. in diameter, and each supporting on one face a double row of zoœcia disposed alternately on each side. Zoœcia ovate, 0·5 × 0·15 mm. (with the neck retracted); neck thick and rather bulbous; surface generally smooth. No gizzard.

Habitat.—Station 188, lat. 9° 59′ S., long. 139° 42′ E., 28 fathoms, green mud.

The distinction between this form and *Vesicularia spinosa* is too obvious to require remark. But there is a second species, which occurred in the "Rattlesnake" collection, and was procured between Cumberland Island and Point Slade, which appears to be very closely allied, and I have, therefore, thought it might be useful to give a description of it, thought not strictly belonging to the Challenger Expedition.

(2) *Vesicularia trichotoma* (Pl. VIII. fig. 4).

Character.—Zoarium of irregular straggling growth, main stems or primary branches about 0·2 in diameter, and usually barren, thick-walled. Primary branching, trichotomous, secondary usually furcate. Secondary and tertiary branches much slenderer, thin-walled. The internodes support eight to ten zoœcia, disposed alternately in a double series on only one side of the branch; in the youngest segments there is only a single row. Zoœcia very readily detached, ovoid, and about 0·4 × 0·2 mm. The surface is smooth and the neck short.

Habitat.—Bass Strait, between Cumberland Island and Point Slade, Voyage of H.M.S. "Rattlesnake."[1]

A peculiarity at once distinctive of this form is the trichotomous division of the primary branches; the great difference in diameter of the branches is also characteristic, as distinguishing it from the preceding, with which it agrees in the alternate arrangement of the zoœcia on the internodes.

2. *Farrella*, Ehrenburg.

Farrella, Ehrenb., Johnst., Busk, Engl. Cyclop.; Hincks, Brit. Mar. Polyz., p. 528, &c.
Lagenella, Farre, W. Thomson, Hassall.
Laguncula, Van Beneden.

Character.—Zoarium stolonate, free, or creeping and adherent; branching irregularly or at definite intervals. Zoœcia cylindrical or subventricose below, pedunculate. Orifice, when the neck (goulot) is retracted, bilabiate or quadrangular. Neck long, tapering, with or without a crown of setæ.[2] (No gizzard).

(1) *Farrella atlantica*, n. sp. (Pl. VII. fig. 3).

Character.—Zoarium stolonate, filamentous, jointed at regular intervals, free or creeping and adnate. Stolon 0·02 to 0·04 mm. in diameter, throwing out three or four short branches or zoœcia close below each joint at regular intervals. Zoœcia with the

[1] This species does not occur in the Challenger collection.

[2] It does not seem to have hitherto been remarked that the genus *Laguncula* (V. B.), as exemplified in *Laguncula repsus* and *Laguncula elongata*, has no setæ.

neck retracted, about 0·4 mm. long by 0·07 to 0·09 in diameter, cylindrical and of uniform diameter throughout, quadrangular at the orifice when the neck is retracted. Supported on a long peduncle. Surface of peduncle and lower part of cells very finely wrinkled.

Habitat.—Off Bahia, 10 to 20 fathoms, mud. On *Amathia brasiliensis* and *Amathia distans.*

Family III. Cylindrœcidæ.

Cylindrœciidæ, Hincks, Brit. Mar. Polyz., p. 534.
Vesiculariadæ (pars), Bk., Alder, Hincks.
Vesicularieæ (pars), Smitt.

Character.—Zoœcia not deciduous, arising from, and apparently continuous with, the stolon or segment from which they spring. Walls earthy or argillaceous.

The Family here contains the following :—

1. *Cylindrœcium*, Hincks.

(1) *Cylindrœcium papuense* (Pl. VIII. fig. 2).

1. *Cylindrœcium*, Hincks.

Farrella (pars), Bk.
Avenella, Hincks, Gosse (*nec* Dalzell).
Cylindrœcium, Hincks, Brit. Mar. Polyz., p. 535.
Vesicularia (subg. *Avenella*, pars), Smitt.

Character.—Zoœcia uniformly cylindrical or slightly ventricose below, sometimes dilated at the base. Stolon slender, creeping, with occasional enlargements. Zoœcia wide apart or sometimes crowded.

(1) *Cylindrœcium papuense*, n. sp. (Pl. VIII. fig. 2).

Character.—Zoarium a creeping adherent stolon with occasional bulbous thickenings. Zoœcia cylindrical, of uniform diameter and not dilated at the base, 1·3 mm. long by 0·1 to 0·11 mm. in diameter, springing either singly and widely apart from the stolon, or four or five together from a bulbous thickening.

Habitat.—Station 188, lat. 9° 59′ S., long. 139° 42′ E., 28 fathoms, green mud. Parasitic on *Amathia semispiralis*, Kirchenp.

The forms known to me as referable to the genus *Cylindræcium* as above defined are :—

(1) *Cylindrœcium giganteum*, Busk.

Farrella gigantea, Bk., Quart. Journ. Micr. Sci., vol. iv. p. 93, pl. v. figs. 1, 2; Gosse, Mar. Zool., pt. ii. p. 22, fig. 40.
Avenella gigantea, Hincks, Ann. and Mag. Nat. Hist., ser. 3, vol. ix. p. 473.
Avenella fusca (*forma producta*), Smitt, Kritisk Förteckn., p. 503.
Cylindrœcium giganteum, Hincks, Brit. Mar. Polyz., p. 535, pl. lxxvii. figs. 3, 4.

(2) *Cylindrœcium dilatatum*, Hincks.

Farrella dilatata, Hincks, Quart. Journ. Micr. Sci., vol. viii. p. 279, pl. xxx. fig. 7.
Avenella dilatata, Hincks, Ann. and Mag. Nat. Hist., ser. 3, vol. ix. p. 473.
Cylindrœcium dilatatum (pars), Hincks, Brit. Mar. Polyz., p. 536, pl. lxxix. figs. 1–3.

(3) *Cylindrœcium fuscum*, Busk.

Farrella fusca, Bk., Quart. Journ. Micr. Sci., vol. iv. p. 94, pl. vi. fig. 3.
Avenella fusca, Alder, North. Cat., p. 69; ? Norman, Shetland Polyz., Rep. Brit. Assoc., 1868, p. 311; Smitt (*forma simplex*), Kritisk Förteckn., p. 503.
Cylindrœcium dilatatum (pars), Hincks, Brit. Mar. Polyz., p. 537, pl. lxxvii. figs. 1, 2.

(4) *Cylindrœcium pusillum*, Hincks.

Cylindrœcium pusillum, Hincks, *loc. cit.*, p. 537, pl. lxxx. fig. 8.

(5) *Cylindrœcium pusillum*, var. "*dwarf*," Hincks.

Cylindrœcium pusillum, var. "*dwarf*," Hincks, *loc. cit.*, p. 538, pl. lxxx. fig. 9.

(6) *Cylindrœcium papuense*, n. sp.

The respective dimensions of the zoœcia in these species, so far as they can be made out (mostly from Mr. Hincks's careful figures), are as follows, given in millimetres:—

	Length.		Breadth.
1. *Cylindrœcium giganteum*, ...	3·5	×	0·20–0·25
2. *Cylindrœcium dilatatum*, ...	0·9	×	0·13
3. *Cylindrœcium fuscum*, ...	1·7	×	0·2–0·3
4. *Cylindrœcium pusillum*, ...	1·3	×	0·10–0·13
5. *Cylindrœcium pusillum*, var., ...	0·7	×	0·1
6. *Cylindrœcium papuense*, ...	1·3	×	0·10–·11

From these dimensions it would seem that the form most nearly approaching that in the Challenger collection is the one named *Cylindrœcium pusillum* by Mr. Hincks, from this, however, it differs in the uniform diameter of the zoœcia, which in the latter become wider or subventricose below.

I may take this opportunity of remarking that the form named *Farella fusca* by me, from specimens collected at Newhaven, Firth of Firth, by Mr. W. Thompson in 1849, and which is considered by Mr. Hincks synonymous with his *Cylindrœcium dilatatum*,

seems to differ so much in its comparative dimensions as perhaps to deserve recognition as a distinct species, which might be named *Cylindrœcium fuscum*, as being the first of the genus to which that appellative was given.

Group B. ENTOPROCTA, Nitsche.

Entoprocta, Nitsche, Zeitschr. f. wiss. Zool., Bd. xx. p. 34; Hincks, Brit. Mar. Polyz., p. 563.

Character.—Both oral and anal orifices lying within the crown of tentacles; no tentacular sheath. Tentacles contractile but not retractile, arranged bilaterally and symmetrically.

Order PEDICELLINEA.

The only order.

Family I. Pedicellinidæ, Hincks.

Polypiaria pedicellinea, Gervais, 1837.
Pedicellinæ, Johnst.
Pedicellinidæ, Smitt, 1867; Hincks, 1880; Jullien, 1885.

Character.—Polypides deciduous, borne on a more or less muscular, rigid or contractile peduncle; united into colonies by a chitinous ramified stem or stolon.

The general characters of the family Pedicellinidæ are so well and succinctly given by Mr. Hincks[1] as scarcely to require further observation. The chief points to be noticed, as he remarks, besides the Entoproctous anal orifice are—

1. That there is no invagination of the anterior region and therefore no tentacular sheath, and consequently an absence of the retractor muscular fibres by which it is retracted in the Ectoproctæ.

2. That the integument is soft and never calcified, and is closely applied to its contents; *i.e.*, there is no perivisceral cavity containing a fluid as in most other Polyzoa, such small space as there is between the inner wall of the calyx and the contained organs is occupied by a more or less delicate parenchymatous tissue. The integument is composed of a very delicate outer membrane lined by a layer of flattened polygonal cells. The outer membrane or ectocyst is prolonged beyond the visceral mass and forms the side of the vestibular cup-like chamber, within the transparent walls of which the tentacles are usually seen coiled. The tentacles arise from the upper edge of the inner surface of this cup, and their outer surface is formed by a prolongation of the transparent ectocyst, whilst the inner is covered by a more opaque layer of ciliated cells. The vestibular chamber is separated from the visceral part of the polypide by a thin lamina

[1] Brit. Mar. Polyz., vol. i. p. 563.

(intra-tentakuläre Leibeswand, Nitsche), through which passes on one side the œsophagus and on the other the rectum.

3. All the Pedicellinidæ are furnished with a more or less mobile stem, which is either flexible and contractile throughout, or as in *Pedicellina gracilis*, partially flexible and partially rigid, or as in *Ascopodaria*, wholly rigid and chitinous, its motions being effected by a peculiar muscular apparatus at the lower end.

The only forms belonging to this Family that I have noticed in the Challenger collection belong to an apparently distinct genus, to which in 1878 I had given the MS. name of "*Ascopodaria*," as stated in Professor Allman's Linnæan address of 1879. In 1880, however, Mr. Hincks, in a description of some Arctic Polyzoa, described and figured under the name of *Barentsia bulbosa*, a pedicelline species, which, though apparently quite distinct specifically from either of the two Challenger forms, evidently belongs to the genus I had already proposed to establish. In strict right of priority of publication, therefore, his name should have precedence over that merely provisionally given by me, and I should without hesitation have adopted it, but since then he has described and figured a second species, referable, from my point of view, to the same genus, under the name of *Pedicellinopsis fruticosa*,[1] thus giving two distinct names to the same generic type. I have, therefore, felt justified in retaining my original appellation, and in regarding *Barentsia* and *Pedicellinopsis* as synonyms. As an additional argument, though one of less weight, in favour of the course I have pursued, I might cite the appropriateness of the title I chose, indicative as it is of the main peculiarity of the genus.

The Family here contains :—

1. *Ascopodaria.*

(1) *Ascopodaria fruticosa*, Hincks, sp. (Pls. IX., X. figs. 1–5).
(2) *Ascopodaria discreta*, n. sp. (Pl. X. figs. 6–12).

1. *Ascopodaria*, Busk.[2]

Ascopodaria, Bk. (MS.), Add. by Prof. Allman, Journ. Linn. Soc. Lond. (Zool.), vol. xv. p. 2.
Barentsia, Hincks, Ann. and Mag. Nat. Hist., ser. 5, vol. vi. p. 285; Vigelius, Bijd. Dierk. Genoot. Nat. Art. Mag. Amsterdam, II. Aflev., pt. 2, p. 85.
Pedicellinopsis, Hincks, *loc. cit.*, vol. xiii. p. 363.
Pedicellina (pars), Sars, Leidy.

Character.—Polypide budding from and supported at the extremity of a chitinous, tubular, perforated stem, which expands below into a cylindrical, barrel-shaped dilatation, lined internally by a layer of longitudinal muscular tissue.

[1] This species is the same as one of the two Challenger forms to which I had given the name of *Ascopodaria socialis* but I have now as a matter of course adopted Mr. Hincks specific name.
[2] From ἀσκός, a wine-skin, πούς, a foot, an illusion to the dilatation at the base of the stem.

The structure of the peduncle is the character by which this genus is distinguished from *Pedicellina*. The pedicel is rigid and chitinous throughout, and depends for its motion on the muscular fibres which line the barrel-shaped expansion at the base; the central cavity of this expansion as well as of the rest of the stem being filled with an extremely delicate parenchymatous tissue.

The anatomy of the polypides appears to agree almost entirely, as far as I have been able to observe it in the spirit specimens, with the very careful descriptions given by Dr. Nitsche in his paper on *Pedicellina echinata*.[1] The whole polypide or calyx is enveloped in a delicate transparent membrane or ectocyst, lined with a more or less distinct tesselated epithelium. The alimentary canal consists of an œsophagus, stomach, intestine and rectum (Pl. IX. fig. 6); the liver cells extending along the upper side of the stomach present the usual deep yellow colour. In all the specimens that I have examined the rectum lies in a horizontal position forming an angle with the rest of the intestine; whether this is its normal position, as it appears to be in the closely allied genus *Urnatella*[2] or whether it merely is the case during a young stage of growth, as mentioned by Dr. Nitsche, I am unable to decide. I have not been able to observe with any certainty the reproductive organs; but in nearly all the polypides of one species, *Ascopodaria fruticosa*, between the stomach and the base of the vestibular cavity, there are two large, round, ovarian masses (Pl. IX. figs. 6, 8, 9), which are separated from one another by a thin lamina (Pl. IX. fig. 9). In the other species these masses are not apparently always present.

Mr. Hincks has suggested[3] that his genus *Pedicellinopsis* would properly include the *Pedicellina gracilis* of Sars; in this I am disposed fully to agree with him and should therefore propose to include it in my genus *Ascopodaria*. Professor Leidy[4] refers to a species of *Pedicellina* found by him in 1859, which, from the short description given, if not identical with *Pedicellina gracilis*, ought also to be placed in this genus. The known species therefore would be four or five, as follows:—

(1) *Ascopodaria gracilis*, Sars.
(2) *Ascopodaria bulbosa*, Hincks.
(3) *Ascopodaria fruticosa*, Hincks = *socialis*, Bk., MS.
(4) *Ascopodaria discreta*, Bk.
(5) *Ascopodaria* (?), Leidy.

(1) *Ascopodaria fruticosa*, Hincks, sp. (Pls. IX., X. figs. 1–5).

Pedicellinopsis fruticosa, Hincks, Ann. and Mag. Nat. Hist, ser. 5, vol. xiii. p. 364, pl. xiv. fig. 3.

Character.—Zoarium arborescent, constituted of thick, erect, chitinous, jointed, branching stems, arising from tubular stoloniform fibres. The deciduous polypides (or

[1] *Zeitschr. f. wiss. Zool.*, Bd. xx. p. 13.
[2] Leidy, *Journ. Acad. Nat. Sci. Philad.*, 1884, vol. ix. p. 12.
[3] *Loc. cit.*, vol. xiii. p. 364.
[4] *Loc. cit.*, p. 14.

calices, Auctt.) are seated on the upper end of slender tubes or pedicels, which are produced into a single or double point on one side at the top; at its base the pedicel dilates into a thick barrel-shaped cylinder (Pl. IX. fig. 7), which is covered by a transparent, ringed, chitinous envelope (Pl. X. fig. 1), lined with a strong muscular layer, the cavity being occupied by a very delicate fibro-cellular tissue (Pl. IX. fig. 14). The chitinous pedicels have four more or less regular longitudinal series of funnel-shaped perforations. These polypiferous peduncles are seated in a cup-shaped hollow, and attached by a much restricted termination in a spiral direction around the upright stems, communication with the interior of which is maintained through a fine funnel-shaped orifice (Pl. XI. figs. 12, 13). The polypides are of the usual pedicelline character, and have a very short flexible stalk, which is attached just within the upper edge of the chitinous pedicels, and when young is continuous with the inner cellular tissue; when mature the polypides appear to be quite cut off from the pedicels on which they are placed, and from which they bud in succession (Pl. IX. fig. 5). The tentacles vary in number from twenty in a bud to twenty-six or twenty-eight in an adult, and are arranged more or less bilaterally and symmetrically. The pedicels and stems are of a bright light brown colour usually; the stems turning nearly black when old. The polypides are white and the barrels white or nearly so, the transparent chitinous envelope being so thin that the white inner layer shows through.

The total length of the calyx and peduncle is 3·5 to 3·8 mm. The polypide measuring about 0·65 × 0·5 mm., the pedicel 2·3 × 0·07 mm., and the barrel 0·75 × 0·5 mm.

Habitat.—Station 163, off Twofold Bay, 150 fathoms.

[Port Philip Heads.]

The arborescent growth of this beautiful species distinguishes it at once from all other known Pedicelline forms, but the rest of its structure leaves no doubt as to its belonging to that order.

At first sight it is difficult to observe that the tentacles are not arranged in a perfectly regular and continuous circle, but here and there indications may be noticed that a wider space does occur between two at opposite sides of the circumference, viz., at the two ends of the symmetrical plane of the animal; the bilateral arrangement is most clearly seen in a young budding Polypide (Pl. X. fig. 2) which appears closely to resemble the figures given by Hatschek[1] in his paper on *Pedicellina echinata*, and also the figure and description by Salensky.[2] The buds arise in succession spirally and somewhat in pairs (Pl. X. fig. 1) round the growing ends of the chitinous stems and branches. Fresh polypides also bud from the ends of the pedicels after others have died and dropped off; that this also occurs in *Pedicellina* has been noticed and described by Salensky,[3] and

[1] *Zeitschr. f. wiss. Zool.*, Bd. xxix. pl. xxx. figs. 39, 40, 45.

[2] *Ann. d. Sci. Nat.*, sér. 6, t. v. p. 36, pl. xv. fig. 36.

[3] *Loc. cit.*, pp. 30, 31.

is mentioned by Professor Leidy[1] as occurring in *Urnatella*, but I have not found it referred to by any other writers on the Pedicellinea.

Pl. X. fig. 1, represents a group of buds at the end of one of the branches, and also shows the barrel-shaped expansion at the base of one of the peduncles, from which the transparent ringed covering has been partially loosened and torn off by the process of boiling. Figs. 3 to 5 on the same plate are taken from sketches made by the late Sir C. Wyville Thomson when the specimens were fresh and alive.

(2) *Ascopodaria discreta*, n. sp. (Pl. X. figs. 6–12).

Character.—The zoarium consists of a creeping stoloniferous stem, jointed at intervals where the branches are given off or where the polypides arise. The deciduous polypides are seated at the upper end of slender chitinous pedicels, which are dilated below into barrel-shaped cylinders that have a thick, ringed, chitinous envelope, and exactly resemble those of the preceding species. The polypiferous peduncles are seated by a broad base on the stoloniform stems; usually singly on the somewhat expanded jointed bifurcation of four branches (fig. 11), but sometimes scattered along the stolons (fig. 12). The chitinous pedicels are irregularily punctured by minute funnel-shaped pores. The polypides are united to the pedicels by a spirally ringed flexible joint (fig. 12). The tentacles are from sixteen to twenty in number. The pedicels and stolons are of a bright brown, horny colour, the polypides white, and the barrels also white or very light brown, appearing darkest when quite young, the chitinous envelope becoming thinner and more transparent as the animal grows older.

The total length varies considerably, apparently according to age; the majority of the older ones measure as much as from 4·25 to 4·4 mm. The polypide being about $0·5 \times 0·4$ mm., the pedicel $3·0 \times 0·6$ mm., and the barrel $0·7 \times 0·24$ mm. This species is, therefore, on the whole, taller and more slender than the preceding one.

Habitat.—Station 135, off Nightingale Island, Tristan da Cunha, 100 to 150 fathoms.

There were very few specimens in all of this species in the collection, and, therefore, it has not been possible to enter into a full and minute examination of the polypide, but it appears to present all the usual Pedicelline characters.

[1] *Journ. Acad. Nat. Sci. Philad.*, vol. ix. pt. i. p. 13.

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GENERA, SPECIES, AND VARIETIES.

(Synonyms printed in *italics*).

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[1] A scale in millimetres is marked near the lower right-hand corner of Plates I.–VIII., which applies to all the figures on each, except where a different scale is marked.

G.B. del. C. Berjeau lith.

Mintern Bros imp.

CRISIA.

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PLATE II.

CRISIA.

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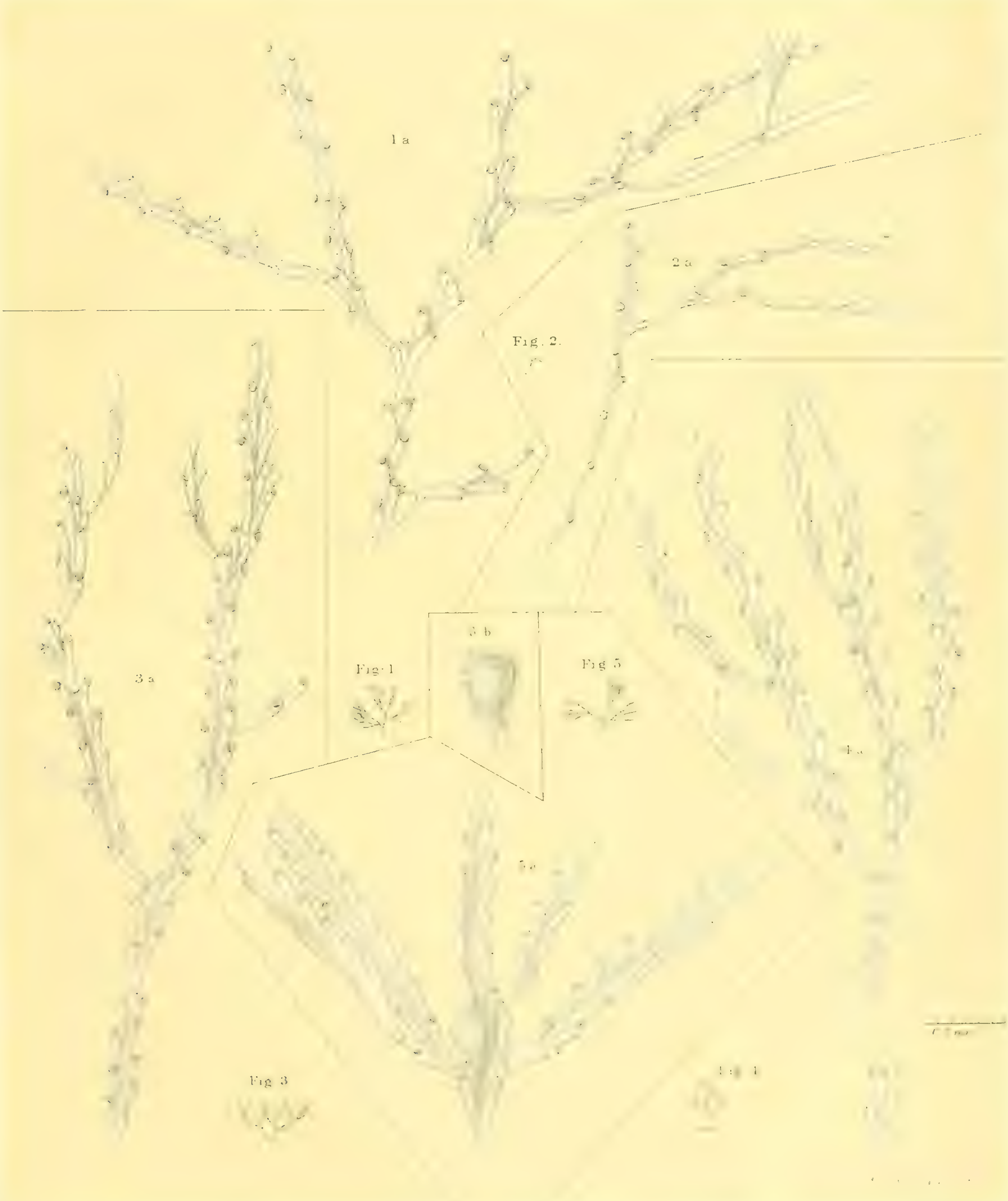

G.B del. C. Berjeau lith.

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CRISIA.

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PLATE III.

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J.B. del.

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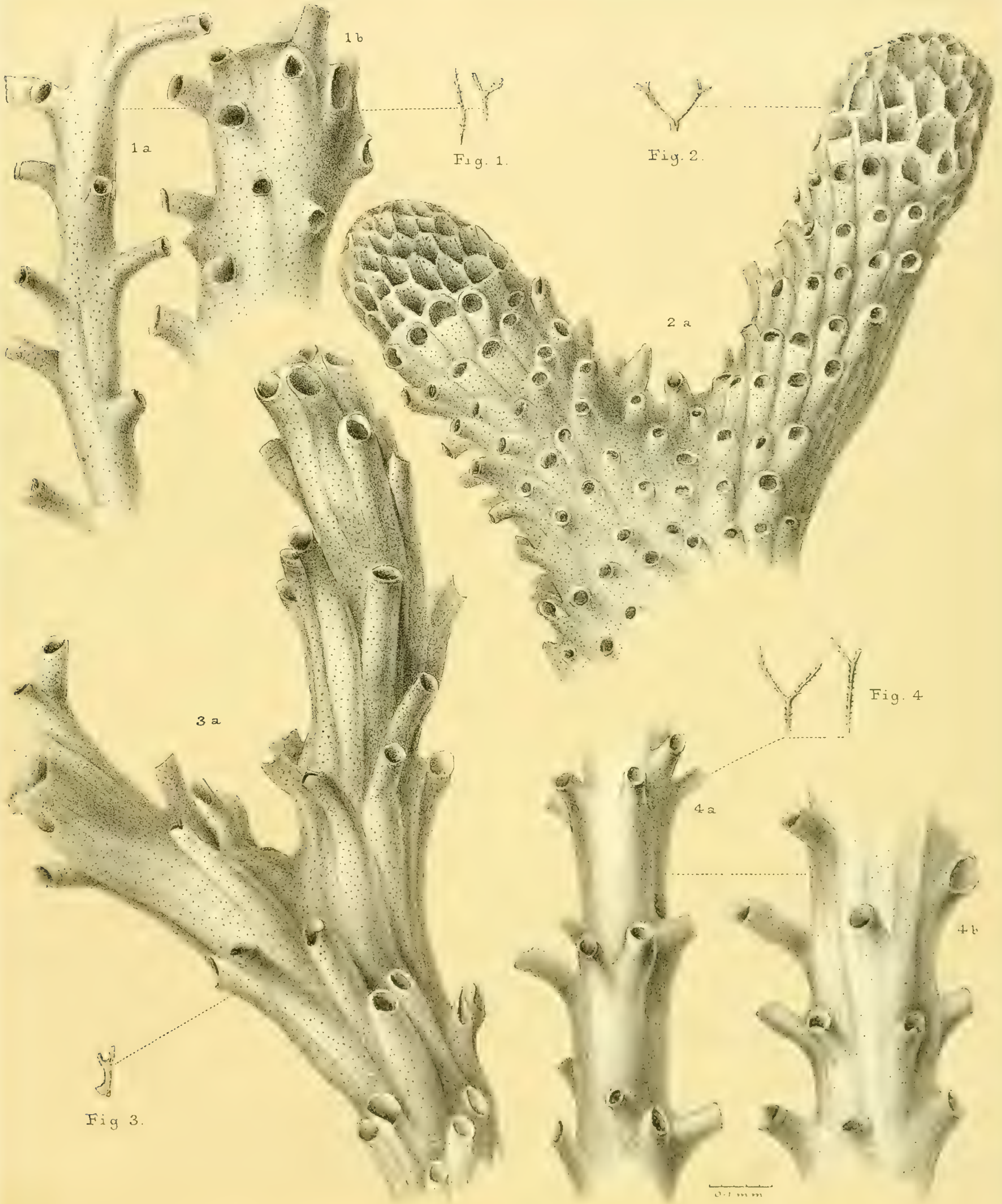

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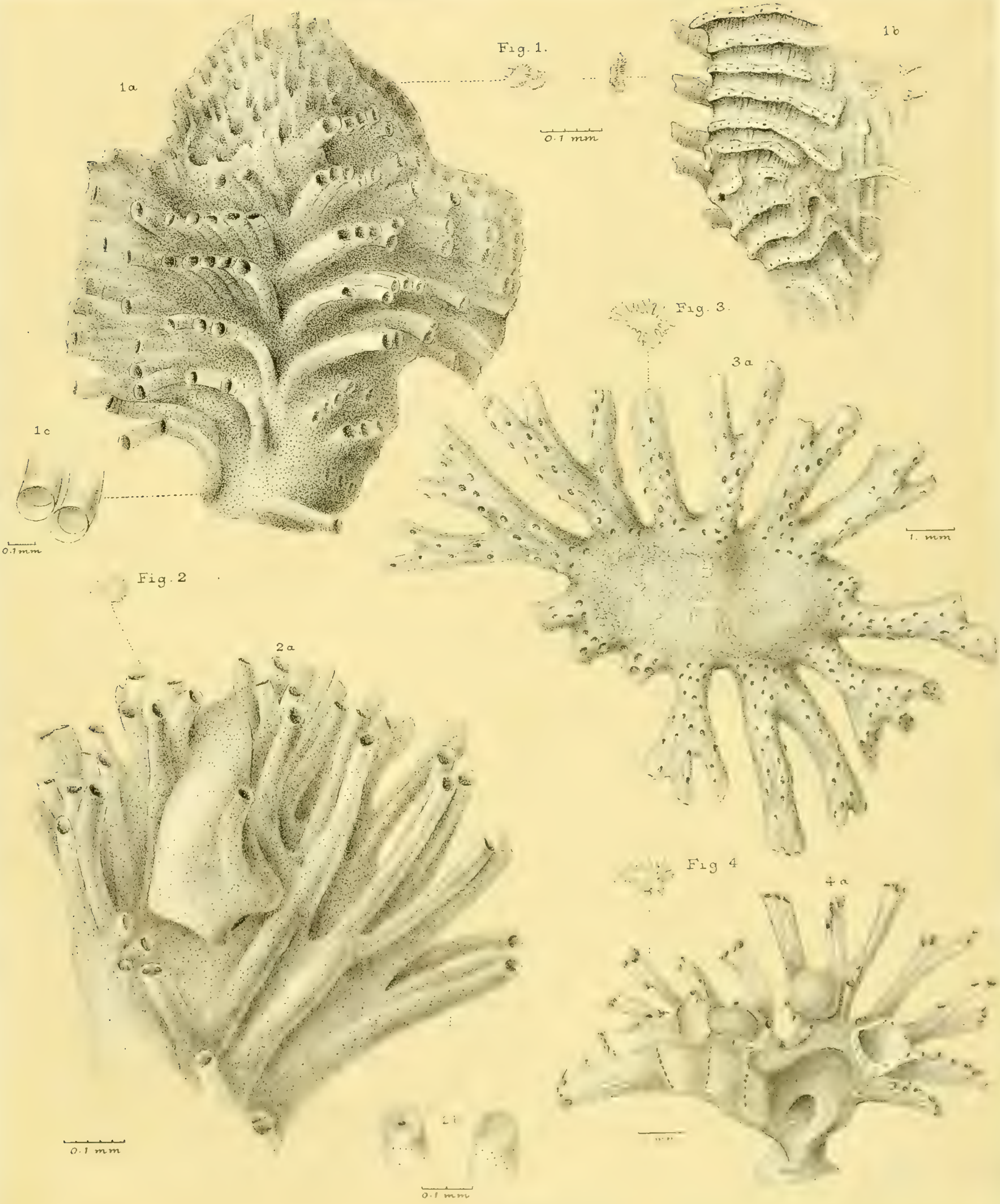

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G.B. & J.B. del.

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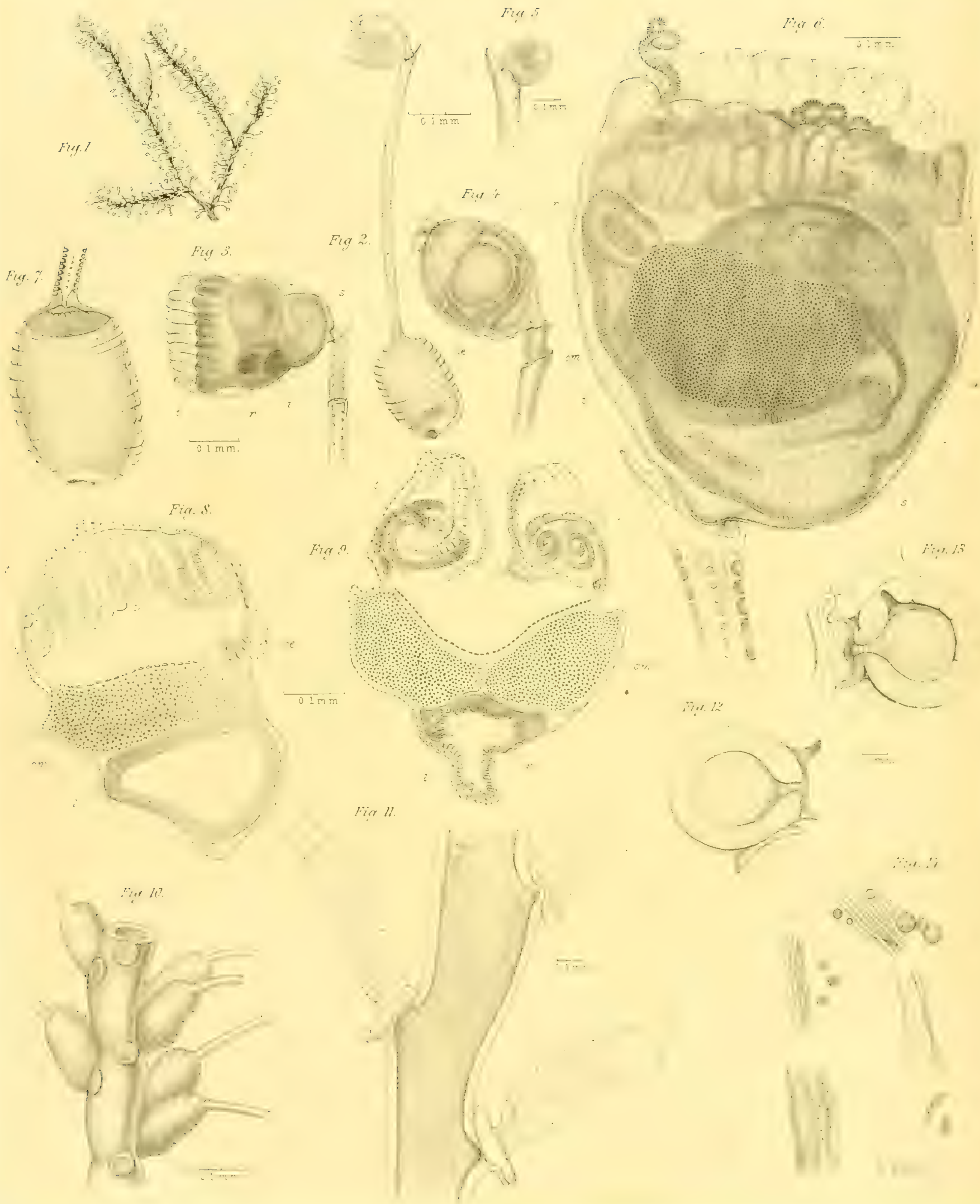
[1] Several references used on this plate:—*i*, intestine; *l*, liver cells; *œ*, œsophagus; *om*, ovarian masses; *r*, rectum; *s*, stomach; *t*, tentacles.



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ASCOPODARIA.

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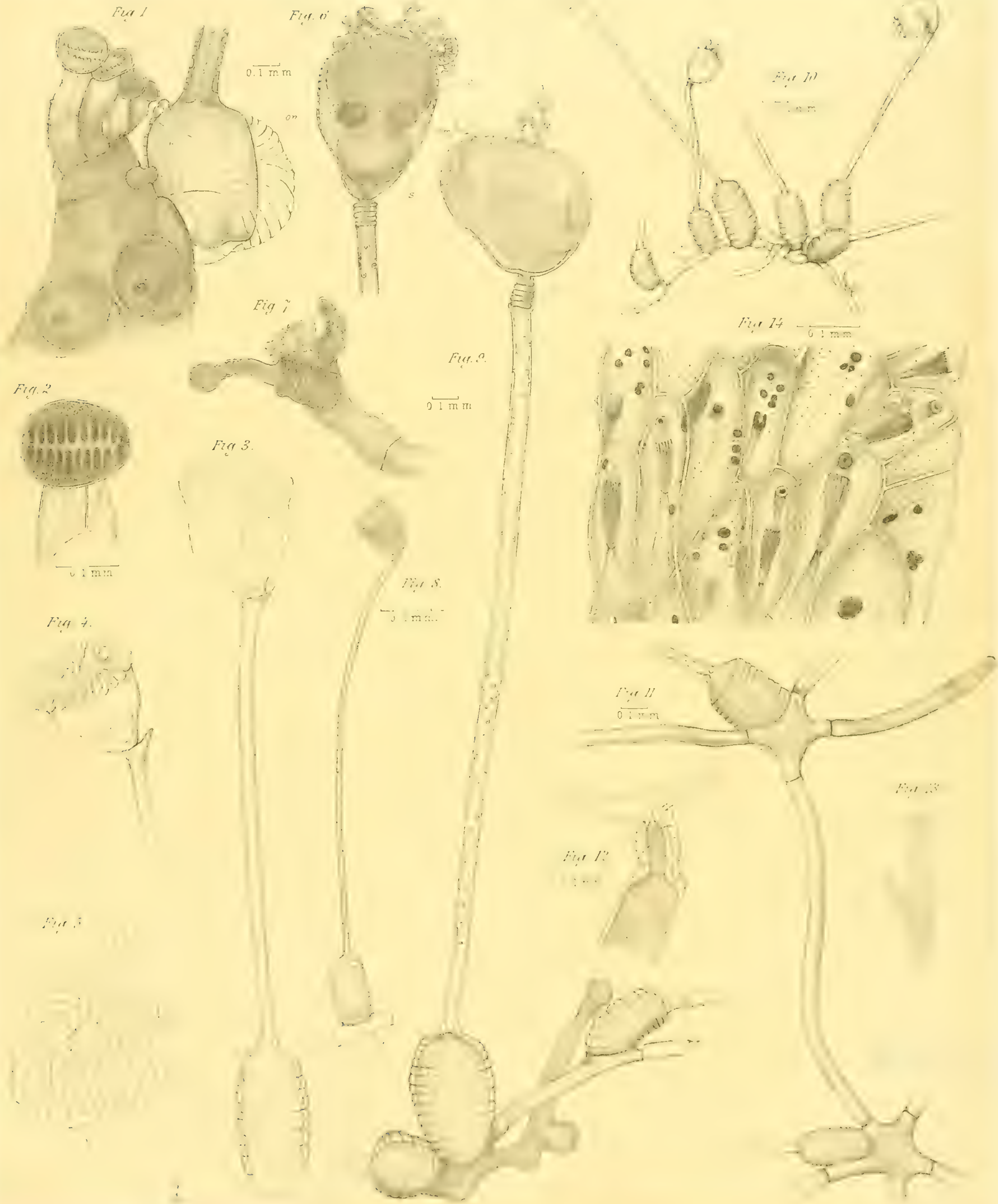
[1] Several references used on this plate:—*i*, intestine; *l*, liver cells; *œ*, œsophagus; *om*, ovarian masses; *r*, rectum; *s*, stomach; *t*, tentacles.



C.W.T., G.B. & J.B. del.

ASCOPODARIA, ALCYONIDIUM.

REPORT

ON THE

SCIENTIFIC RESULTS

OF THE

VOYAGE OF H.M.S. CHALLENGER

DURING THE YEARS 1873-76

UNDER THE COMMAND OF

CAPTAIN GEORGE S. NARES, R.N., F.R.S.

AND THE LATE

CAPTAIN FRANK TOURLE THOMSON, R.N.

PREPARED UNDER THE SUPERINTENDENCE OF

THE LATE

Sir C. WYVILLE THOMSON, Knt., F.R.S., &c.

REGIUS PROFESSOR OF NATURAL HISTORY IN THE UNIVERSITY OF EDINBURGH
DIRECTOR OF THE CIVILIAN SCIENTIFIC STAFF ON BOARD

AND NOW OF

JOHN MURRAY, LL.D., PH.D., &C.

ONE OF THE NATURALISTS OF THE EXPEDITION

ZOOLOGY—VOL. XXVI.

PART LXXIII.—REPORT ON THE ACTINIARIA—SUPPLEMENT

BY PROFESSOR RICHARD HERTWIG

Published by Order of Her Majesty's Government

PRINTED FOR HER MAJESTY'S STATIONERY OFFICE

AND SOLD BY

LONDON:—EYRE & SPOTTISWOODE, EAST HARDING STREET, FETTER LANE

EDINBURGH:—ADAM & CHARLES BLACK

DUBLIN:—HODGES, FIGGIS, & CO.

1888

Price Four Shillings

PRINTED BY MORRISON AND GIBB, EDINBURGH.
FOR HER MAJESTY'S STATIONERY OFFICE.

EDITORIAL NOTE.

THE Report on the ACTINIARIA, by Professor Richard Hertwig, was published in 1882, forming Part XV. of the Zoological Series of Reports, in Volume VI., Zoology.

This Part forms the Supplementary Report promised at that time on a number of forms which reached Professor Hertwig too late for the descriptions to be included in the original Report. It consists of 56 pages of letterpress and 4 lithographic plates.

The manuscript was received 21st January 1888, and the Memoir was translated from the German by G. Herbert Fowler, Esq., Ph.D., of University College, London.

JOHN MURRAY.

CHALLENGER OFFICE, 32 QUEEN STREET,
EDINBURGH, 21*st June* 1888.

THE

VOYAGE OF H.M.S. CHALLENGER.

ZOOLOGY.

REPORT on the ACTINIARIA dredged by H.M.S. Challenger during the years 1873–1876. By Prof. RICHARD HERTWIG.

SUPPLEMENT.

INTRODUCTION.

AFTER I had concluded my Report on the Actiniaria of the Challenger Expedition, a number of additional specimens were sent to me, on which I now present a short Supplementary Report. Unfortunately the work has been delayed longer than I could have wished, partly on account of a series of experimental investigations upon the fertilisation and segmentation of the ovum, which I had undertaken in concert with my brother, but mainly owing to the claims on my working-time caused by my transference from Königsberg to Bonn, and from Bonn to Munich.

Amongst the material occurred several specimens of species which have been previously described and can therefore be treated in few words; besides these, there are also several new forms, representing new and interesting genera, which require a detailed description, and which are, for the sake of clearness, designated by an asterisk. At the end (p. 54) will be found a list of those Actiniæ of which a systematic study was impossible, either because they were not sufficiently well preserved, or because their appearance was no longer characteristic owing to the absence of sculpturing and colour, the necessary result of the method of preservation.

Since the publication of the earlier part of this Report, the great monograph of Angelo Andres on the Actiniaria has appeared.[1] During the progress of his work this

[1] Fauna und Flora des Golfes von Neapel, Le Attinie, 1884.

author was acquainted only with the short preliminary notice of my researches published in the Jena Proceedings,[1] not with the Report itself; a fact easily understood when one considers how long before the date of publication a monograph constructed on such a plan must be completed. In his comprehensive revision of the Actiniæ, and re-definition of families and genera, he has been prevented from referring to my contemporaneous attempt at revision, since this first appeared in the detailed Report. As it is most desirable that two systems, appearing within a short time of one another, should be brought into such relation as to avoid future discordance and mistake, I accept with pleasure the opportunity of a critical utterance on their mutual relations.

As against the six chief divisions into which I divide the Actiniæ (Hexactiniæ, Paractiniæ, Monauleæ, Edwardsiæ, Ceriantheæ, Zoantheæ), Andres erects seven, viz. Edwardsinæ, Actininæ, Stichodactylinæ, Thalassianthinæ, Zoanthinæ, Cerianthinæ, Minyadinæ. With regard to three chief groups we are in complete accord (Edwardsiæ, Ceriantheæ, Zoantheæ), except for the fact that Andres, in my opinion, relies on too inconstant and unimportant external characters; while, as I have shown, these groups, at least, admit of anatomical characterisation by the arrangement of their mesenteries, and thus can be far more clearly and sharply circumscribed. If the reader compare in this connection the definitions of the Zoantheæ furnished by myself and by Andres, it will be readily admitted that none of the characteristics of the latter author, such as colony-formation or incrustation, are constant within the group; that, on the other hand, all the forms follow one and the same law of mesenterial arrangement, first recognised by G. von Koch.

If we carry the comparison further, we find that Andres places beside the Actininæ, as separate groups, the Thalassianthinæ, the Stichodactylinæ, and the Minyadinæ; though with a certain caution, as having himself studied no representative of them. I believe that he has here exceeded the systematic value which can be safely assigned to the form of the tentacles and their distribution on the mesenterial chambers. I have studied certain Stichodactylinæ (*Corallimorphus rigidus*, *Corallimorphus profundus*, and *Heterodactyla hemprichii*), and of the Thalassianthinæ, *Thalassianthus aster*, and can assert, as the result of a thorough examination of their structure, that in all important points they agree with the hexamerous Actiniæ; nor have I any doubt that these forms, even if united into separate families, must be ranged among the Hexactiniæ. Finally, the group of Minyadinæ has for many reasons, which I entirely recognise, undergone at the hands of Andres so sharp a criticism, that one can hardly see why he retains it, or why at least he does not allow it to rank merely as a subdivision of Hexactiniæ, until the necessity of its removal from that group is rendered apparent by anatomical investigation.

From the point of view explained, I am of opinion that all the forms referred to

[1] *Jenaische Zeitschr.*, Bd. xv. p. 10, 1881.

by Andres must be comprehended in the four divisions, Edwardsiæ, Hexactiniæ, Zoantheæ, and Ceriantheæ, and accordingly hold to the systematic classification which I have published. The groups of Paractiniæ and Monauleæ are in all respects natural, and would also certainly be retained by Andres had representatives of them been known to him.

Even greater discordance than that of which I have hitherto spoken, between the classifications of Actiniæ followed by Andres and myself, presents itself when the determination and nomenclature of families and genera are regarded. Independently of each other, and from different standpoints, we have taken in hand a systematic revision of Actiniæ: Andres starting with the advantage of a richer material, and studying species with which earlier publications are especially concerned, and which he could command in a living condition; while my qualification for a systematic classification was that afforded by close anatomical investigation, namely, that I relied for systematic characteristics upon such weighty differences as the structure of the sphincter, the arrangement of the mesenteries, the structure of the musculature and of the oral disc, etc., points which Andres has, hitherto at any rate, entirely left out of consideration. Thus it has resulted that in the determination of families and genera, and also in the value assigned to existing names, we have in many cases taken up a totally different attitude; and as, in consequence of this, no inconsiderable confusion has arisen in the method of diagnosis, I hold it advisable to inquire critically what must be retained of the system of the Italian observer.

Of least importance are our differences of opinion relating to those Actiniæ which possess acontia. Andres has here adopted the separation, instituted by Verrill, into Sagartidæ and Phellidæ. Having regard to his wider acquaintance with the species, I agree with him in accepting as a distinctive character the chitinous covering extending over two-thirds of the body-wall; and for clearer characterisation of both families the following marks not mentioned by Andres should be included in the diagnosis,—a mesodermal sphincter, and a differentiation of the mesenteries into sterile complete primary mesenteries, and incomplete secondary mesenteries provided with generative organs. Of the Challenger Actiniæ, there would belong to the Phellidæ only *Phellia pectinata*; to the Sagartidæ, *Sagartia sp.*, *Cereus spinosus*, *Calliactis polypus*, *Bunodes minuta*. Of these, the two latter require an alteration of name; *Calliactis polypus* must be termed *Adamsia polypus*,[1] and *Bunodes minuta* be known as *Cylista minuta*, since it has been shown by Andres that the typical *Bunodes* possesses no acontia, and therefore cannot belong to the Sagartidæ.

Andres has incorrectly allowed the generic name *Cereus* (Oken) to drop, and has

[1] The specific name *Rondeletii* has been wantonly substituted by Andres for the older *polypus*, the former being used for the first time by delle Chiaje in 1825, while the latter was already instituted by Forskål in 1775. Milne-Edwards is therefore correct in calling the animal *Adamsia polypus*.

introduced in its place the more recent name *Heliactis*, for Sagartidæ with numerous large papillæ; although Oken adduces *Cereus bellis* as the type form, which stands in the same relation to the genus *Heliactis*. The papillate Sagartidæ are of two kinds, the one having a soft surface, while in the other the body-wall is covered as far as its upper edge with a bark-like cuticle which recalls the Phellidæ; it is therefore advantageous to confine to the former the name *Heliactis*, applied, though unjustifiably, by Andres, and for the latter to restore *Cereus*, the old designation of Oken, a representative of the newly characterised genus being *Cereus spinosus*.

In discussing the families instituted by Andres, we next come to the Paractidæ. As I understand the diagnosis given for this family,—"margine tentaculato, non rilevato e privo d' acroragi,"—the tentacles spring at the edge where body-wall and oral disc pass into one another, just as is the case both in the Corallimorphidæ and Antheomorphidæ, which I have described in more detail, and, generally speaking, in such Actiniæ as are devoid of a circular muscle. But this relation also holds good in Actiniæ with a weak sphincter, as, for example, in *Anemonia cereus* (to which Andres, strange to say, ascribes a "margine rilevato"); and, finally, in Actiniæ, in which the sphincter is developed at some distance outwards from the upper edge of the body-wall. The facts adduced are sufficient to prove that this characteristic is systematically useless; and in addition to this I insist that the few forms grouped in the family do not appear to agree with the diagnosis. The tentacles of an *Anemonia* are, according to Andres, formations placed more at the edge than are those of a *Paranthus* or a *Paractinia*. On the contrary, the *Paractis peruviana*, which Andres adduces as the type of the family, seems to me to have no tentacles which would be marginal. Indeed, it agrees so entirely with a Challenger form, *Paractis excavata*, that I long doubted whether it were not right to unite the two. In *Paractis excavata*, I am certain that a strong mesodermal sphincter is present, and, corresponding to this fact, body-wall and oral disc are sharply marked off from each other, whence I conclude that the same holds for *Paractis peruviana*. Since I have thus good ground for holding unsuitable the methods by which Andres has instituted his family Paractidæ, and can, in addition, claim the right of priority, I adhere to the definition which I previously published, leaving only to future investigators to decide upon the advisability of erecting Actiniæ with marginal spherules, sucking-papillæ, and papillæ into a family separate from the Paractidæ (*sensu stricto*) with smooth body-wall.

The next family in the system of the Italian naturalist is formed by the Actinidæ, and corresponds to the Antheadæ and Actinidæ of Gosse. I formerly followed Gosse in separating these two families, but had previously maintained that anatomically they are closely related, and should perhaps on that account be united. I have therefore nothing to adduce against this proceeding of Andres, though the detailed investigation of the Actinidæ, which I recommended, has not yet been carried out. It is also

correct to replace the name *Anthea* by the older *Anemonia*, and to range the genus *Comactis* under it. On the other hand, my *Comactis flagellifera* is not identical with *Anemonia sulcata* (*Anthea cereus*), and should therefore be referred to as *Anemonia flagellata*.

In the system of Andres the Bunodidæ bear the closest relation to my family Tealidæ. I was unacquainted with any typical *Bunodes*, and had supposed (*cf. supra*) that they possessed acontia. This supposition is, according to Andres, incorrect; and the close relationship to *Tealia* is thus anew proven. Accordingly I withdraw the name Tealidæ in favour of the older designation Bunodidæ; but, now as formerly, the endodermal sphincter must occupy the first place in the diagnosis. I relinquish, however, to future observers, as with the Paractidæ, the decision whether forms with smooth and with papillate body-wall should be separated from one another, or not.

A last point of dispute with Angelo Andres lies in the fact that I reckon the *Halcampæ* among the Ilyanthidæ, while he erects them into a separate family. I will not decide in this place either for the one opinion or the other, but will discuss merely the point of view, which, as it seems to me, must be of importance for a decision.

The more we have learnt in late years of the structure of these forms, the more has it become apparent that Actiniæ, which are rounded posteriorly and devoid of pedal disc, exhibit in most cases a sort of ancestral character; eminently primitive forms are, above all others, the Edwardsiæ. Among such forms is the genus *Halcampa*, from which again the genus *Halcampella* is a transition to the remaining Actiniæ, in virtue of its numerous tentacles, and of its commencing to exhibit accessory mesenteries. I opine that the genus *Ilyanthus* stands in close relation to the *Halcampellæ*; the regular increase of the mesenterial pairs by multiples of six, which is commencing in the one case, is in the other clearly expressed, as may be inferred from the presence of the numerous longitudinal furrows of the body-wall; while the siphonoglyphes (ciliated grooves), the hinder edge of the body, and the sphincter, are obviously of weak development, as among the *Halcampæ*. Possibly a study of the mesenteries may yield further points of agreement, but, unfortunately, nothing is accurately known of these important features in the structure of *Ilyanthus*; and so long as this is the case, no conclusion can be certain. If my expectations be confirmed, a union of the *Halcampæ* with the Ilyanthidæ would be desirable; the latter would form a transitional family placed at the top of the Hexactiniæ, and bridging the gap between them and the Edwardsiæ; while, as a peculiar and aberrant branch of the Actiniæ, would be ranged near them the Siphonactidæ, the forms possessing a conchula.

All the forms of which we have as yet spoken possess the typical digitate or tubular Actinian tentacles, so arranged that one tentacle corresponds to each radial chamber; there are, however, two variations of this arrangement. In the one

the tentacles are replaced by appendages of a different value, for instance, by stomidia in the Liponemidæ which I have described, or by bushy or arborescent growths in the families Sarcophianthidæ and Thalassianthidæ erected by Andres. On the other hand, there are forms in which more tentacles than one correspond to a mesenterial chamber; accessory tentacles, placed on the oral disc, being present in addition to the primary tentacles. This is conclusively proved only for species of *Corallimorphus*, but Andres has rendered it excessively probable also for species of *Corynactis* (compare the account of *Corynactis*? sp. ? p. 10, *infra*). For such forms I have instituted the family Corallimorphidæ, Andres the family Corynactidæ. I believe that my designation deserves preference, because it is the older, and because my diagnosis of the family alone insists upon the important anatomical characteristic; on the other hand, I concede to the Italian naturalist that the family may be restricted to species with knobbed tentacles, and that all Actiniæ with modified tentacles, of which an accurate investigation is still required, may be brought under a series of further families.

For a comprehension of the above discussion, I give a view of that arrangement of Hexactinian families which I hold the most advantageous, in the form of a synoptic table.

A few changes have been made in the English terminology used in the former part of this Report: "œsophagus" has been replaced by "stomatodæum," "mesoderm" by "mesoglœa," and "œsophageal groove" by "siphonoglyphe."

SYNOPSIS OF THE FAMILIES OF THE HEXACTINIÆ.

A. Hexactiniæ with simple wreath of tentacles.

- Tentacles
  - digitate. Pedal disc
    - absent. Siphonoglyphes and sphincter obscure
      - without conchula...... *Ilyanthidæ.*
      - with conchula.......... *Siphonactinidæ.*
    - present. Acontia
      - present. Sphincter mesodermal. Cuticular covering...
        - absent....... *Sagartidæ.*
        - present...... *Phellidæ.*
      - absent. Sphincter...............
        - absent.................................... *Antheomorphidæ.*
        - present
          - weak.......................... *Actinidæ.*
          - strong, endodermal.......... *Bunodidæ.*
          - strong, mesodermal.......... *Paractidæ.*
          - mesodermal. Transverse axis elongated... *Amphianthidæ.*
  - abnormal in shape..
    - clavate, knobbed .... *Heteractidæ.*
    - replaced by stomidia............. *Liponemidæ.*
    - branching or bushy ....
      - *Sarcophianthidæ.*
      - *Thalassianthidæ.*

B. Hexactiniæ with double or multiple wreath of tentacles... *Corallimorphidæ,* etc.[1]

[1] (*Cf.* Andres, *op. cit.*, p. 264.)

DESCRIPTION OF GENERA AND SPECIES.

Tribe I. HEXACTINIÆ.

Family, CORALLIMORPHIDÆ, R. Hertwig.

Genus *Corallimorphus*, Moseley.

Corallimorphus rigidus, Moseley.

Amongst the supplementary material I have found the original specimen on which Moseley formerly founded the species *Corallimorphus rigidus*. I had already mentioned this on Moseley's authority in my earlier Report, though I had not myself seen it, and had described from my own observation four more specimens, of which one, from Station 157, agreed in all essential particulars with the three others from Station 146. I am now in a position to confirm the statement that the three latter agree with Moseley's specimen in form, in colour (of which traces only remain in spirit specimens), and in the condition of the body-wall,—they exhibit no thickenings, but merely forty-eight longitudinal furrows corresponding to the insertions of the mesenteries. Another specimen, from Station 299, also agreeing with Moseley's type, is of interest, since, of the twenty-four tentacles on the oral disc, one accessory tentacle of the first order is duplicated, two little tentacles being planted close together. I have already described a similar, though more strongly expressed, development of supernumerary tentacles in *Corallimorphus profundus*, so that it appears probable that the law of increase in the tentacles of Corallimorphidæ is not yet so definite as among other Actiniæ, and allows of more variation than in other cases.

Corallimorphus obtectus, n. sp.

While the five last-named specimens agree with one another, that from Station 157, on which I chiefly based my former description, demands a separate position, so that I now account it the representative of a new species to which I give the name *Corallimorphus obtectus*, having regard to the buckle-like thickenings which cover the insertions of the mesenteries. A further difference lies in its disc-like shape, due to the relations of size between pedal and oral disc. Both are in this case of the same size, but in *Corallimorphus rigidus* the former is considerably the smaller, producing a saucer-shaped profile. The two species may be differentiated by the following diagnosis :—

1. *Corallimorphus rigidus*.—Twenty-four tentacles are planted on the oral disc,

and forty-eight at its edge; the insertions of the mesenteries are recognisable by longitudinal furrows; the oral disc essentially larger than the pedal.

In addition to the examples referred to above, there belongs to this species one specimen from Station 299, December 14, 1875; lat. 33° 31′ S., long. 74° 43′ W.; depth, 2160 fathoms.—Dimensions, height, 1·3 cm.; breadth of the oral disc, 4 cm., of the pedal disc, 1·7 cm.

2. *Corallimorphus obtectus.*—Twenty-four tentacles are situated on the oral disc, and forty-eight at its edge; the mesenterial insertions are covered, in the lower third of the body-wall and the peripheral third of the pedal disc, by cylindrical thickenings; the pedal and oral discs of approximately the same size.

To this species belongs only the example from Station 157, with which my former description was concerned.

Genus *Corynactis*, Allman.

Corynactis (?) sp. (?)*

The tentacles, both on the disc and at its edge, are knobbed; those on the disc are arranged in several circles, so that more than one tentacle communicates with each intra-mesenterial chamber.

Habitat.—Station 219, March 10, 1875; depth, 150 fathoms.

Dimensions.—Diameter of the oral disc, 2·5 cm.; height of the column, 0·8 cm.; greatest length of the tentacles, 1·6 cm.

Angelo Andres gives in his monograph a description of the genus *Corynactis*, based partly on personal observation, partly on the account of Allman, from which I infer that, with one and the same radial chamber communicate one of the marginal tentacles and, in many radii, several of those placed on the disc; five cycles are present, of which the first contains four tentacles, the second sixteen, the third, fourth, and fifth twenty-four. Gosse records other numbers, namely, four rows with sixteen, twenty-four, thirty-two, and thirty-two tentacles respectively. In such remarkable contradiction, one may well doubt whether one has any right to deduce a law of position from either account; and the descriptions of the manner of distribution of the tentacles are so inadequate, that it is impossible to conjecture how many of the tentacles placed on the disc correspond to a radial chamber.

Amongst the Challenger material was an Actinian which I originally took for a *Corallimorphus*, till I recognised that on four radii of the body two tentacles on the disc and one at its edge proceed from one and the same radial chamber. This is in contradiction to the law of the position of tentacles in *Corallimorphus*, but on the other hand is related to that in *Corynactis;* to the latter genus I therefore provisionally refer it, even though many characters do not agree in the two forms. Especially is its shape divergent, being saucer-like as in *Corallimorphus*, and not elongated as in *Corynactis*. Further,

the animal is very irregularly developed; the number of marginal tentacles amounts to fifty-six, larger and smaller generally alternating; two cycles, each of twenty-eight, might thus be recognised, did one not consider that the tentacles of each cycle differ markedly and somewhat irregularly in size. One is compelled to rank under the primary circlet, tentacles which in diameter are far short of tentacles of the second order. Even more irregular is the arrangement of those tentacles which are situated on the disc: their total number, twenty-three, falls into three cycles, six tentacles being placed near the mouth (oral tentacles), ten near the edge (peripheral tentacles), and seven intermediately. Despite these apparently irregular numbers, I have noticed the complete validity of a law in one-half of the animal, and it is of importance that this regular half commences with the one pair of directive mesenteries and reaches to the other, thus just completing one side of the animal. In the half in which a regular arrangement is followed, we have three oral, six intermediary, and six peripheral, accessory tentacles. The six intermediary alternate with the six peripheral, three of them standing on the same radius as the oral tentacles. If we compare with these the marginal tentacles, the larger twelve are on the radii already occupied by the tentacles on the disc, while the smaller twelve are placed on the intermediate radii. At each of two points two tentacles are present, a larger and a smaller; and, being out of accord with the law which governs Actiniæ, are either a token of the commencement of further growth, or constitute a case of those numerous abnormalities which occur in the group.

In the other half of the animal occur important gaps in the ground plan just quoted. The three oral tentacles are in the same place as in the other half, (one is over the chamber bounded by the directive mesenteries), but five of the intermediary tentacles and two of the peripheral are wanting. The single intermediary tentacle occurs in the region bordering on the directive mesenterial chamber just mentioned; this region is normally arranged, the peripheral tentacles being also present on it. As with the tentacles on the disc, so also the marginal ones exhibit great irregularities; their number amounts to twenty-eight; in size their relations are also variable, so that the rule, that larger and smaller tentacles alternate, is in places infringed.

The peculiar results of a macroscopic examination induced me to cut out a sextant of the animal for a closer study by means of sections, choosing that sextant of the normal side which contained the directive septa, and which only departed from the regular scheme of the Hexactiniæ in the presence of two supernumerary tentacles. The results were, that the mesenteries are grouped in pairs by the arrangement of their muscles thus,—one pair of directive mesenteries, and four other pairs, all of which reach to the stomatodæum. Of these four pairs I reckon one in the second cycle, two in the third, the remaining pair being developed asymmetrically and repeating the irregularity already noticed in the tentacles.

From the intra-mesenterial chamber of the directive septa are evaginated thre

tentacles; besides the marginal, one oral tentacle and one intermediary are placed on the disc. In the intra-mesenterial chamber of the second order the former (oral) was wanting; in those of the third order, the intermediary tentacle was also wanting, or rather was replaced by a peripheral tentacle. From all the inter-mesenterial chambers, and also from the supernumerary intra-mesenterial chamber, spring only marginal tentacles.

Histologically our *Corynactis* is closely related to the *Corallimorphi.* The mesoglœa is homogeneous, branched stellate cells are richly scattered in it, while the modified bladder cells, which occur in *Corallimorphus obtectus*, are wanting. Beneath the endoderm runs a fibrous layer, sometimes closely under it, sometimes separated from it by a homogeneous layer, giving off bundles which run to the endodermal surface. The musculature of the oral disc and tentacles is weak and ectodermal; there is no special sphincter, and the mesenteries are provided with only weak muscles on both sides. On the other hand, I was surprised at the *occurrence of longitudinal muscles on the outer side of the body-wall.* They are not very strong, and are mostly composed of short spindle-shaped fibres, the lamella being always slightly pleated here and there. This discovery made it necessary to study *Corallimorphus obtectus* anew, with reference to the body-wall. The epithelium having been preserved only at exceedingly few spots, constituted the reason why I had not previously observed the muscle, but a renewed study yielded figures by which I arrived at the following definite opinion, based on numerous preparations from different parts of the body.

At the basis of each epithelial cell lies a small body, staining in carmine, and resembling, in sections accurately transverse to it, a muscle fibril. If the section be taken at an angle of about 30°, these bodies appear elongated and somewhat spindle-shaped; but I have seen no such obvious longitudinal fibres as in *Corynactis.* I am therefore of opinion that *Corallimorphus* possesses longitudinal muscles, but that they are extremely rudimentary.

The observation of ectodermal longitudinal muscles on the body-wall of *Corynactis* is an exceptionally interesting discovery. Among all Anthozoa, we know of a similar condition in *Cerianthus* alone, and, as I may here mention, anticipating future investigation, in *Arachnactis*, a genus very closely allied to *Cerianthus:* while in the typical Anthozoa the ectodermal musculature is confined to the tentacles, the oral disc, and the stomatodæum. On the other hand, all Hydroids in the hydra-form (*i.e.* Hydroid-polypes and Scyphostomæ) possess ectodermal longitudinal muscles of the body-wall, which are prolonged directly into the tentacles and oral disc (peristome). We have here, throughout the whole body, circular muscles on the endodermal side, and longitudinal, *i.e.* radial, on the ectodermal.

On the ground of previous researches on the sexual organs, I have published the view, since defended by Götte, that the Scyphomedusæ are ancestral forms of the

Anthozoa, the development of radial (mesenterial) folds which commences in the former being further advanced in the latter. In this case the ectodermal longitudinal musculature of *Corynactis* and the *Cerianthi* would be, as it were, heirlooms from the Scyphostomæ. Both genera would thus retain an ancestral character no longer to be found elsewhere among Anthozoa, with which would agree that both genera must on other grounds be placed near to the original ancestor of the group. Of all Hexactiniæ, the Corallimorphidæ are, next to the *Halcampæ*, the most primitive; the Cerianthidæ again must be derived from the extremely primitive Edwardsiæ.

Family 2, Antheomorphidæ, Hertwig.

Genus *Ilyanthopsis*, n. gen.

Antheomorphidæ with the tentacles in several rows; body-wall smooth; body goblet-shaped, broadening upwards from the small pedal disc to the broad oral disc.

Ilyanthopsis longifilis,* n. sp. (Pl. II. fig. 2).

Tentacles very long, pointed, with an obvious terminal pore, ranged in four circlets, increasing in length from the centre outwards.

Habitat.—Reef of the Bermudas, June 1873. One specimen.

Dimensions.—Diameter of base, 4 cm., of oral disc, 7 cm.; height, 3·5 cm.

The single specimen, which was well preserved but strongly contracted, in its shape occupies a middle position between *Aiptasia* and *Anemonia*. The base is relatively small, the body not very high, but broadening out conically towards the mouth. The body-wall being raised in goblet shape over the edge of the oral disc, the animal possesses a "collar" in the sense of Angelo Andres, and consequently, owing to the absence of cinclides and acontia, must be reckoned near the Ilyanthidæ. From these it differs in the presence of a well-developed pedal disc, by which it undoubtedly attaches itself to rocks.

The thin body-wall is smooth, except for transverse wrinkles due to the strong contraction of the mesenteries. No sphincter is present. The circular muscle-lamella is, in all parts of the body-wall equally, pleated into muscular laminæ, which are low, and either not at all or only slightly arborescent.

The tentacles are very numerous, and are arranged in four rows, the oral disc being free from them in the immediate neighbourhood of the mouth. Since I counted but 160, not all the tentacles of the sixth order can as yet have been developed. The longest of them were some 4 cm. in length, and 0·5 cm. broad at the base; the slightly truncated tip possessed a small pore. In studying the ectodermal muscle-lamellæ, peculiarities presented themselves which suggested the longitudinal muscles on the outer surface of the body-wall in *Cerianthus*. The muscular pleats are generally

slightly arborescent, as is shown in Pl. II. fig. 2, and arranged close to one another like the leaves of a book. At the free edge of the pleat the musculature is interrupted, since here the fibres of the mesoglœa, which serve as foundation for the muscle-pleat, radiate into the epithelium. For some distance they are united in a bundle; they then part, and each fibre individually tends in the direction of the epithelial surface. The nerve-fibre layer is consequently pierced by fine fibrils, arranged parallel to and at equal distances from one another. I would have gladly determined how far the connective tissue fibres reach, and whether they are connected with individual epithelial cells or not; but in thin sections I could only follow them into the dim granular striated layer of epithelial cells, in which they were no longer distinguishable from other fibres. Attempts to exhibit the isolated fibres by brushing and agitating thin sections, or by maceration in alkali, yielded no result; and staining with picrocarmine was also unsuccessful. The latter generally stains the mesoglœal structures of a deep red, and is therefore peculiarly adapted for exhibiting the mesoglœal lamina which carries the muscles, but it refuses to differentiate the fibrils. The red tint is therefore only seen to extend so far as is expressed in the figure by shading; the fibrils probably do not stain, but only the cement substance uniting them. The condition here described may be followed on to the oral disc, inasmuch as the supporting laminæ of the muscle pleats here also run out in fibres, and the individual fibres radiate to the epithelium. I have only further to remark that radial furrows, shallow and slightly expressed, run from the edge of the oral opening towards the tentacles.

The stomatodæum, in the only specimen which I could examine, was evaginated, and consequently so tightly stretched that even the siphonoglyphes were almost smoothed out, and hardly recognisable.

The mesenteries agree in number with the tentacles; all reach the stomatodæum, and bear generative organs. The younger mesenteries touch the stomatodæum somewhat further back, and are in other respects less developed than the older; but their generative organs are more voluminous than those of the first and second orders. Stomata in the mesenteries, and acontia, I have not been able to recognise.

Family 3, Actinidæ, A. Andres.

Antheadæ, Hertwig.

Genus, *Hormathia*, Gosse.

Actiniæ with broad diffuse endodermal sphincter; smooth thin body-wall, and parietal spherules (*i.e.* marginal spherules placed on the body-wall).

Hormathia delicatula,* sp. n. (Pl. II. figs. 1, 3, IV. fig. 9).

More than 160 tentacles; parietal spherules tentacle-like, one of the latter to about every four tentacles.

Habitat.—(?) (Inscription on the label completely soaked away). Two specimens.

Dimensions.—Diameter of the nearly spherical body, 2·5–3·0 cm.

Gosse has conferred the name of *Hormathia margarithæ* on an Actinian brought up by the line of a deep-sea fishing-boat. Having obtained but one specimen, and that not till some time after death, he could give but an incomplete description; the most important point of which is that on the delicate body-wall, at some distance from its upper edge, are placed prominences resembling marginal spherules, the number of which is about ten, and is essentially less than that of the tentacles. In his monograph treating of the Actiniæ, Angelo Andres has included the animal among the doubtful genera, as being of uncertain systematic position. It was therefore very agreeable to me to find in the Challenger material two Actiniæ obviously belonging to the genus *Hormathia*, by the study of which I am enabled both to justify the creation of a new genus, and also to define accurately its systematic position.

Both specimens were so strongly contracted as to resemble an apple in shape. The upper part of the body-wall, the pedal disc and the mouth being entirely drawn in, and the latter covered over, one saw at first only the lower part of the body-wall, the smooth surface of which was so little characteristic that I came near to ranking the animal among the undeterminable forms. Only after dividing a specimen longitudinally did the circlet of parietal spherules come into view, their position being characteristic of the genus *Hormathia*.

The pedal disc is strongly constricted and pleated by the violent contraction. The body-wall is exceptionally delicate, so that the septa are plainly visible through it, and is quite smooth. By a circular fold, which recalls to mind the boundary between body-wall and oral disc, and marks the limit of retraction in a withdrawn specimen, is bounded a separate invaginable region of the body-wall; close up to this fold, and on the side nearest to the oral disc, is placed a circlet of 42 knobs, which are hollow and beset with nematocysts, and which therefore recall the structure of the marginal vesicles or "bourses marginales" (Pl. IV. fig. 9). They are of different sizes, the largest generally longer than the marginal spherules; and are curved in a digitate manner at the end, so as to present some resemblance to tentacles. The number of tentacles and mesenteries being about 160, the parietal spherules, as I term these structures, are not placed, like the marginal spherules, one on each inter- and intra-mesenterial chamber; but there is one spherule to about every four chambers, with one of which it is always in communication, leaving the remaining two or three free.

The marked retractibility of the animal is effected by a sphincter muscle in a definite region of the body-wall, which, commencing at some little distance from the

parietal spherules, and reaching to the origin of the tentacles, extends therefore over a fairly wide belt. Correspondingly to this broad extension, it is nowhere strongly developed, and falls under the category of "diffuse" endodermal muscle, the lamella being most markedly pleated in the centre. Its arrangement is very characteristic, as a transverse section presents the appearance of numerous closely-packed acinose glands, excavated in the mesoglœa. In the more central parts—to continue the comparison—the gland-like crypts are longer and more closely packed than in the upper and lower parts (Pl. II. fig. 1).

The strongest development of muscles occurs on the ectodermal side of the disc, where the supporting lamina rises into high plates, covered by strong fibrils and richly arborescent. Here and there I have also noticed the plates fusing together, with a resultant mesodermal inclusion of the muscle fibrils (Pl. II. fig. 3). Towards the tentacles the muscles become weaker.

The tentacles are of a medium length, broad at the base, and drawn out to a fine point, which is probably not provided with an opening at the tip. The siphonoglyphes are hardly marked on the stomatodæum. To the latter, besides the mesenteries of the first cycle, those of the second and third cyles at least are attached. Their musculature is in no region strongly developed; in the specimen investigated nearly ripe testicular follicles occurred on them.

Family 4, Bunodidæ.

Genus *Aulactinia*, Verrill.

Aulactinia,* sp. (?)

Habitat.—Simon's Bay, Cape of Good Hope, December 1873; 10–20 fathoms. One specimen.

Dimensions.—Height in a strongly contracted condition, 2 cm.; breadth of pedal disc, 3 cm.

In this place I will devote only a few words to a Bunodidan, of which I reserve a detailed description till I shall have reviewed a rich supply of species of this family which has been forwarded to me. The body-wall of the sole specimen lying before me is thickly beset with thin-walled vesicular outgrowths, which are about 1 mm. in size, show a tendency towards arrangement into transverse and longitudinal rows, and are so thickly set that the intermediate stouter parts of the body-wall have a reticulate appearance. The three upper rows of these vesicles (about seventy in number) are closely packed with nematocysts, and so take on the character of marginal spherules; they may be distinguished into a stalk, and a branching head like a cauliflower. They recall somewhat those external appendages of species of *Oulactis*, which

have been termed,—I do not know for what reason,—tentacles. The tentacles are arranged in three rows, and more than 200 are present. The endodermal sphincter is extraordinarily strongly developed, in the form of a ridge projecting into the cœlenteron.

Family 5, Paractidæ.

Genus *Dysactis*, Milne-Edwards.

Dysactis crassicornis, R. Hertwig.

Two additional examples of this Actinian, have reached me, dredged from a depth of 55 fathoms at Station 313. One had died in an expanded condition, so that the tentacles were in better preservation than in the specimens previously studied; from this I am enabled to determine some further characters of these organs.

In many cases terminal pores, which I was before unable to discover, were easily recognised on a surface view; I have therefore re-investigated the older material, and was able with some trouble to prove the existence of openings by injecting air into them under water.

Further, in the well-preserved tentacles, comes strongly into view a characteristic which I had previously figured (former Report, pl. vii. fig. 12), but had not introduced into the text; the tentacles are longitudinally striated, so covered with longitudinal ridges and furrows as to recall a fluted pillar; in section this is still more prominent. At tolerably regular intervals the mesoglœa rises in high ridges (Pl. II. figs. 6, 7), and at these points the mass of muscle lying in it is correspondingly increased. The muscles therefore form in transverse section a continuous ring, which in the region of the ridges of mesoglœa is drawn out into cusps. At the base of an especially strong tentacle I counted twenty-two longitudinal ridges, of which, however, some only reach to the tip.

Family 6, Liponemidæ, R. Hertwig.

Genus *Liponema*, R. Hertwig.

Liponemidæ with weak endodermal sphincter; the body-wall marked by longitudinal furrows, without marginal spherules; stomidia very numerous.

Liponema multiporum, R. Hertwig (Pl. I. fig. 13, Pl. II. fig. 4).

Stomidia, several hundreds in number, distributed in several cycles, and scattered over the whole oral disc; body apparently cup-shaped, broadening out from the small pedal disc upwards to the wide oral disc.

Habitat.—(*a*) Station 305, January 1, 1876; 120 fathoms. One specimen.

(*b*) Station 147, December 3, 1873; 1600 fathoms. One specimen.

Among the Actiniæ with degenerate tentacles, I described in my former Challenger Report a new species, in which the extent of retrogression of the tentacles can be recognised in a degree attained by no other form. I was compelled to dispense with a detailed description of its structure, since the only specimen at my disposal was on the one hand much mangled, and on the other rendered so brittle by preservation in chromic acid that it could not be methodically investigated. I am glad to be in a position to fill up the deficiency by means of two specimens found in the supplementary material, both well preserved, although considerably altered in shape by violent contraction. In both cases, as in the example previously described, the stomatodæum is so much evaginated as to take the place usually occupied by the oral disc, the latter falling outwards from this point like a body-wall (Pl. I. fig. 13). On the other hand, pedal disc and body-wall are alike deeply retracted on the lower side. The body-wall forms a cup like the shell of a *Patella*, the pedal disc projecting into the cup somewhat like the body of the *Patella*. In so marked a de-formation, dimensions can with difficulty be given, and can serve only for approximate orientation. In the larger of the two specimens (from 120 fathoms at Station 305), the pedal disc had a diameter of about 2 cm., the distance between the edge of the oral disc and the mouth reached 2·5 cm.; the length of the stomatodæum was at most places 1·5 cm., and at the siphonoglyphes more than 2 cm. The corresponding dimensions of the smaller example (Station 147; depth, 1600 fath.) are essentially less,—diameter of pedal disc, 0·07 cm.; radius of oral disc, 1·2 cm.; length of the stomatodæum, 1·0 cm. From the nature of the contraction may be inferred that in both cases the dimensions of oral disc and stomatodæum are excessive, as the result of evagination, while those of the pedal disc are too small.

On the pedal disc are about 160 radial furrows, of which, however, only a proportion reach the centre, the rest dying out sooner or later. The ridges between the furrows are somewhat toothed, in the manner formerly described by me as occurring in *Polystomidium* and *Polysiphonia*. In the centre of the pedal disc lies a pit about the size of a pin's head, which cannot be proved to be an opening.

On the exterior of the body-wall also, similar ridges, alternating with furrows, run longitudinally from pedal to oral disc; their number is greater, being close on 400; they differ in size, some few of less considerable development rising between every two of the stronger ridges. At the edge of the oral disc they all pass into a strong circular ridge, which forms the sharp boundary between body-wall and oral disc.

The pedal disc and body-wall possess on their inner surfaces the circular muscle-fibre layer occurring in all Actiniæ; on the body-wall this is strongly pleated, and the more so, the nearer we approach to the upper edge. In the immediate neighbourhood of the edge the pleating is so marked that one may term it a sphincter; it causes here the circular ridge mentioned above as occurring at the upper edge of the body-wall

(Pl. II. fig. 4). This circular ridge appears in transverse section as a pushing out of the body-wall, the circular muscle exhibiting a very different structure in the different regions. At the base of the organ the pleating of the muscle-lamella is insignificant, indeed weaker than at other points of the body-wall, but at both edges of the evagination it is exceptionally strong, and more especially so at the boundary of the oral disc. When the section comes to the actual spot on which one of the stomidia is set, the inner sphincter—as we call the nearest muscular pleating—is beautifully recognisable as a ridge projecting inwards, into the axis of which protrudes a mesoglœal ingrowth. From this axial ingrowth are given off on both sides richly branching mesoglœal lamellæ, clothed by powerful muscle-fibres in transverse section. At the remaining points, where the oral disc presents no stomidia, the sphincter is less clearly bounded, and resembles more the outer sphincter, which is essentially nothing but an approximation of muscular folds at two closely-adjacent points.

Relatively to the size of the animal, both sphincters are weak; a consequence of this is the fact that they have not drawn up the body-wall over the mouth disc, but that stomatodæum and oral disc have rather been pressed outwards.

The oral disc recalls in appearance a toadstool, having a faintly flesh-coloured surface, covered by whitish, slightly elevated spots. These spots are the stomidia or tentacles, which are distributed nearly up to the mouth, leaving but a narrow strip free. Between the stomidia the radial furrows run in undulating lines. Their number is difficult to determine, but may amount to about 400.

The stomidia are openings in the oral disc, surrounded by a slightly developed ridge, and projecting a little above the surface; roughly speaking, they are distributed uniformly over the oral disc, or allow only of a vague distinction into several zones. Of these zones one is peripheral, set close to the edge of the oral disc; one is central, not far from the oral opening; and two intermediate zones are placed between them. The openings increase in size from without towards the centre, and at the same time undergo an alteration of shape; in the peripheral zone they are like radially-set slits, with a long axis of 0·7–1·5 mm.; in the intermediate zones they are circular, with a diameter of 1–2 mm.; and in the central they again form slits of 2·0–2·5 mm. in the longer diameter, but are here placed at right angles to the radii.

The structure of the stomidia can best be exhibited by figures of transverse sections. Each stomidium completely occupies the intermediate space between two neighbouring mesenteries, and forms a tube, opening peripherally by a wide mouth. The walls of the tube appear in section to be direct continuations of the adjacent septa; morphologically their lower part is to be regarded as oral disc, their upper part as rudimentary tentacle; accordingly, they exhibit below the numerous muscular pleatings which at other points cause the radial ridges on the oral disc, while above these pleatings are absent. A remarkable structure is a small circular fold projecting below into

the lumen of the tube, and constricting it like a diaphragm. This doubtless serves to close the tube, since it is covered by a marked layer of muscle fibres, running circularly round the opening.

Where no stomidium is placed, the oral disc exhibits on its ectodermal side a thick layer of radial muscle fibres, arranged in simple lamellæ, which, at most, branch but once. The lamellæ being higher midway between two mesenteries than elsewhere, the radial ridge-like thickenings of the oral disc are the result.

With reference to the relations between the stomidia and the inter- and intra-mesenterial chambers, in my former publication I expressed the opinion that a intra-mesenterial chamber might carry more than one stomidium, *Liponema* thus approximating to the Corallimorphidæ; an opinion which I can now designate as erroneous, on the ground of more accurate investigation. Each intra-mesenterial chamber possesses but one stomidium, which is the more closely approximated to the centre of the oral disc, in proportion as its adjacent septa are of older formation.

The stomatodæum is brownish-violet in tint, and 2 cm. long; on it are placed the marked siphonoglyphes, about 1·5 cm. in breadth, projecting considerably at the lower part of the tube, where they pass into the boat-shaped stomatodæal cone. They are bounded by two stout, transversely pleated, lips. Further, the stomatodæum is marked by about 200 longitudinal folds, of which some 80, by their stronger build, deserve the name of primary folds. Between every two primary folds lie, in many cases, two secondary folds; but at some places one only may occur, or they may be entirely wanting.

The number of mesenteries was determined by the method before mentioned, that of cutting out a sextant of the animal and studying it closely anatomically. I found six cycles, in all therefore 192 pairs of mesenteries. In the first four cycles all the mesenteries reach the stomatodæum, though those of the first two cycles only are attached to it for its whole length; they all possess wide openings near the edge of the lip (internal mesenterial stomata), and their muscular nature so far preponderates that only those of the fourth cycle carry generative organs. In this respect these mesenteries of the fourth cycle agree with those of the fifth and sixth, but the muscular development of the latter is considerably inferior to that of the others. The mesenteries of the sixth cycle are practically nothing else than small genital folds, projecting but slightly into the cœlenteron, and never provided with mesenterial filaments.

Of the generative organs I found exclusively the testicular follicles, containing spermatozoa in parts ripe, in parts only commencing to develop.

It is possible that in this animal a further growth takes place, with the formation of new mesenteries; this I infer from the great number of stomidia. In the sextant investigated they amounted to about 120, or to 700–800 for the whole animal. Since only about 196 intra- and inter-mesenterial chambers are present, and each of the

former possesses but one stomidium, the latter apparently must be provided each with two or three,—an inference confirmed by dissection. Since it is the rule amongst Actiniæ that the development of tentacles precedes that of mesenteries, we can also infer in this instance from the plentiful development of stomidia, an imminent addition to the mesenteries.

Genus *Aulorchis*, n. gen.

Liponemidæ, whose generative organs are modified into a tube perforating the oral lip; gonidial grooves on both sides drawn out into a long ear-like cone.

Aulorchis paradoxa,* sp. n. (Pl. I. figs. 9, 10; Pl. III. figs. 2–6; Pl. IV. figs. 1–6).

Stomidia arranged in two alternating rows, approximately sixty in number.

Habitat.—Station 299, December 14, 1875; lat. 33° 31′ S., long. 74° 43′ W.; depth, 2160 fathoms. One specimen.

Dimensions.—Height, 4 cm.; greatest breadth (measured about half-way up the animal), 3 cm.

Among the accessory Challenger Actiniæ occurs this form, of great interest as enlarging by a new genus and new species the group of forms devoid of tentacles. Unluckily, I have had but the one solitary specimen for study, and even this was badly preserved, and had apparently suffered much from the dredge. It was exceedingly contracted; oral and pedal discs were externally unrecognisable, since both ends of the body-wall were closely drawn together. As a natural result of this condition, I have not been able to clear up many important points of the organisation so well as I could have wished. For investigation, I divided the specimen longitudinally, and dissected a sextant with scalpel and scissors, arriving at the following results.

The strongly contracted, and therefore small, pedal disc exhibits indistinct radial brownish wrinkles and furrows, and is sharply marked off from the body-wall, the surface of which is smooth. The latter is of a whitish tint, and of inconsiderable thickness, only here and there becoming more powerful, but never forming hooks or papillæ. Its consistence is less firm than that of cartilage, but considerably more so than that of Medusan mesoglœa. The tissue is of a fibrous nature, composed of very fine fibrils, which are generally interlacing and reticulate. At many points, however, they are thicker and bound together in more parallel series, so that cords and lamellæ are formed, which, though staining brilliantly with carmine, are not sharply differentiated from their surroundings. These lamellæ are ranged parallel to the two surfaces, and run constantly closer to one another till a firmly united mass of fibres is formed just below the epithelium. At other points, however, the fibres are more loosely plaited, so that spaces remain between them, which are filled up by homogeneous mesoglœa In some places I detected hollow spaces in the tissue, which were devoid of an epithelial

lining. They occur also in the mesenteries, the stomatodæum, and the oral disc, and may perhaps be caused by inadequate preservation.

In the upper part of the body-wall lies, close under the endoderm, a mesodermal sphincter muscle, its length amounting to about 1 cm., while its greatest breadth reaches 5 mm. at the upper end, from which point it gradually thins out. It is of interest from several points of view ; in the first place, the muscle-fibres are abnormally strong ; consequently the muscle-bundles are formed of but few elements, and consist in many cases only of two to four. Again, the individual tracts are so far from running parallel to one another that in a longitudinal section many bundles are cut absolutely transversely, others obliquely, and others for long stretches superficially ; thus an appearance of extremely entangled fibres is presented (Pl. III. fig. 3*a*).

Finally, *Aulorchis* affords proof of the endodermal origin of the mesoglœal muscle-bundles, as we find on the endodermal side every transition from the mesoglœal bundles to the endodermal layer of circular fibres ; in one place the bundles lie close under the fibrous layer, at another are in communication with it by a broader or narrower band ; finally, we find slight infoldings of the endodermal muscle-layer (Pl. III. fig. 3*b*).

The stomidia lie in two alternating rows between the edges of the mouth and of the body-wall, somewhat nearer to the former ; they are about sixty-four in number (thirty-two between two pairs of directive mesenteries). The stomidia of the inner row are larger than those of the outer ; the smallness of the latter producing the impression, that they have just been formed, and that a further increase of their number is taking place. Radial ridges on the oral disc start at the edge of the body-wall and run up to the individual stomidia.

Transverse sections through the oral disc exhibit a strong mesodermal musculature ; this is interrupted along the lines of mesenterial insertion, and falls therefore into marked radial bands which cause the radial ridges of the oral disc. The individual muscle-bundles contain a few strong fibres, and are so separated from one another by mesoglœal sheaths, stout or slight, that the lines of mesoglœa form dendritic figures springing now from the ectodermal, now from the endodermal side (Pl. III. fig. 2).

The mesoglœa sends into the ectoderm arborescent supporting offsets, on which to my surprise I was unable to find muscle-fibres. It seems as if in *Aulorchis* the ectodermal musculature is completely wanting ; I would gladly have expressed something definite on this point, had the histological condition of the animal not been so indifferent ; but the ectoderm, where present, was unfortunately reduced to a detritus, in which no structure could be detected.

In order to demonstrate how the stomidia penetrate the thickness of the oral disc, I have drawn two figures, in the one of which (Pl. III. fig. 4) are seen the openings of the tube to the exterior and to the cœlenteron ; in the other (fig. 5) the section passes through a spot where the stomidial tube is closed at both ends, whence it may be

inferred that its diameter is here considerably greater than that of the two openings. The radial mesodermal muscle-fibres pass into its walls with a longitudinal trend.

On the stomatodæum are placed the two siphonoglyphes, which are of a very characteristic appearance, as being more powerfully developed than in any Actinia which I have as yet seen; each projects over the mouth edge and upwards with two long ear-shaped cones. The groove itself is correspondingly deep and broad, pleated, and of a cartilaginous consistence. Between the two siphonoglyphes run on each side about ten strongly-marked longitudinal ridges, terminating in rounded knobs on the lip.

In investigating the mesenteries, I could at least prove their arrangement in pairs, but could not convince myself that the Hexactinian symmetry was carried out. Neither by microscopic preparations of a sector, nor by dissection of individual mesenteries, could I arrive at a definite law of arrangement; this point therefore requires investigation.

The mesenteries dissected bore no generative organs; these appeared to me to be confined entirely to one mesentery, and to possess a tubular structure unparalleled in the whole class of Anthozoa, a fact which decided me to choose for the genus the name *Aulorchis*. Even before dissection it had struck me that at a spot on the edge of the lip, and by a pore specially present for the purpose, was the opening of a cylindrical organ; this organ had obviously once been longer, as at its end a fracture was clearly recognisable. By splitting up the opening and the adjacent stomatodæum, the organ, which I will term in future, for reasons to be mentioned, the genital tube, could be clearly followed into an inter-mesenterial chamber (Pl. I. fig. 9). It meets one of the complete mesenteries, lies at this point embedded in the tangle of mesenterial coils, and, as appeared later from sections, ends at the mesentery in a horseshoe-shaped curve. The curved portion was firmly united with the mesentery. Transverse sections yielded further conclusions relative to its structure; but, unfortunately, owing to bad preservation, no exhaustive account of this is possible. For instance, I have not been so fortunate as to determine how far the structure of the genital tube can be referred to that of the ordinary Actinian ovary (Pl. IV. figs. 1–6).

The genital tube is superficially clothed by epithelium, which is limited externally by a border resembling a cuticle, but perhaps produced only by mucous secretion; then follows the mesoglœa with the ova embedded in it; internal to these lies a cavity, more or less spacious according to the mass of the ova. The mesoglœa is divided by a narrow granular layer into inner and outer zones, which here and there, by failure of the intermediate layer, join together. The outer zone is narrow, and exhibits what appear to me to be circular muscle-fibres referable to the epithelium, which in longitudinal sections through the organ (fig. 3) resemble narrow laminæ placed close together. The state of preservation was inadequate for the determination of the histological character of the granular median layer; in transverse

section it gave the impression of a disintegrated epithelium, in longitudinal, it resembled a loose connective-tissue. This layer is important as containing small, spherical, deeply-staining cells, which I regard as young ova. The masses of ova are in parts so considerable as to present the appearance of mosaic, if part of the wall of the genital tube be cut out, stained, and viewed from the surface (fig. 2). Next comes the second zone of mesoglœa, the layer of most importance, since ova of various sizes are embedded in it. Some of these are certainly connected with the superficial epithelium; this condition, I believe, occurs in all ova, and is effected by the fibre-arrangement characteristic of Actinian ovaries, of which remnants only could here be detected (fig. 1).

The lumen of the tube was mostly filled by a cell-detritus, but at some points was lined by a clearly ciliated epithelium (figs. 4, 6); I reckon therefore the lumen as a ciliated canal, serving for the transit of ripe ova and perhaps also of embryos, and opening to the exterior outside the oral disc. The ripe ova appear to lie on the floor of the tube, since here I found compact masses of a finely granular substance, appearing to me to resemble ova.

As to the distribution of the ova in the genital tube, I have the following facts to add: the smaller ovules are met with in sections through the upper part of the tube, forming a ring, on the one side of which the generative elements are more closely packed than on the other. This lop-sided development of sexual cells is expressed more obviously lower down, where on one side of the section they are entirely wanting, the ripening ova being only present in the other half.

With regard to the connection of the genital tube with the body of the Actinia, I have arrived at no positive results. At the pore, the organ merely perforates the oral lip without being attached to it, as I can assert both from macroscopic dissection and transverse sections; while at the lower end I have discovered no intimate connection with the mesentery; what I saw there was only an epithelial adhesion, not a transition from the mesoglœa of the mesentery into that of the genital tube. Such a connection, however, must certainly occur at this point.

From my description it may be recognised that *Aulorchis* is one of the most interesting Actiniæ, and that it would be very desirable that a richer material of it should be acquired by fresh Deep Sea investigations.

Family 7, PHELLIDÆ.

Genus *Phellia*, Gosse.

Phellia spinifera, n. sp. (Pl. II. figs. 8, 9).

The bark-like part of the body-wall is bedecked with thorn-like pointed knobs, distributed more richly on the upper than on the lower parts.

Habitat.—(*a*) Station 311, January 11, 1876; depth, 245 fathoms. Three specimens. (*b*) Station 320, July 14, 1876; depth, 600 fathoms. One specimen.

Dimensions.—Length of the contracted animal, 2·5–3·2 cm.; breadth, 2·5–3·5.

At first I was inclined to refer the three specimens from Station 311, which were seated on Molluscan shells, and the single specimen from Station 320, to *Phellia pectinata;* for they possessed the characteristic appearance of the body-wall, resembling the tunic of *Cynthiæ,* while the upper indrawn part of the wall presented the ridged surface which has been already figured. I was, however, persuaded to a closer study by observing some points of divergence in the structure of the peripheral region of the body-wall. The transverse and longitudinal ridges are wanting, instead of which occur knobs, resembling those of *Cereus spinosus;* these start with a broad base, and terminate in a slightly truncated tip; they are distinguished from the body-wall, which is nearly white, by a brownish tint, and may amount to 200 in number, distributed more abundantly on the upper than on the lower regions of the body-wall. The upper knobs are as much as 0·25 cm. long, and are more strongly developed than the rest; they become gradually smaller below, and finally appear only as fine grains. Such an arrangement of the knobs in series, as exists in *Bunodes,* does not occur.

The mesoglœa of the body-wall is so extraordinarily stiff as to cause some trouble, before good sections of the sphincter can be effected. The latter is essentially constituted as in *Phellia pectinata,* so that reference to the description given under that species is sufficient. In position it is considerably nearer to the ectoderm than to the endoderm.

The oral disc and stomatodæum are of a brownish violet (partially altered in the alcohol), the former lighter in tint than the latter. On the stomatodæum the two siphonoglyphes, which are not pigmented, and are consequently of a whitish yellow, strike the eye on opening the animal as two broad, sharply-marked, stripes. They are only distinguished from their surroundings by this difference of colour, since they are flush with the rest of the stomatodæum. They are crossed by transverse folds regularly arranged, which are continuous over the rest of the stomatodæum. Further, the stomatodæal cone is hardly expressed at all, and the longitudinal furrows, which so commonly run parallel to the siphonoglyphes between the mesenterial insertions, are wanting.

For the characterisation of the species the condition of the musculature of the oral disc is also of importance; it exhibits two methods of formation. In the one case it is purely ectodermal and markedly pleated, the pleats running parallel to one another, and only slightly arborescent (Pl. II. fig. 9). At other points (fig. 8) the arborescence is very considerable, the individual branches anastomosing with one another; the musculature thus becomes partly mesoglœal, and a very obvious and stout muscle-layer arises. The muscle-fibres are here, as in the sphincter and the powerfully developed laminæ of the retractors, of exceptional thickness.

All the mesenteries are unusually muscular; the primary mesenteries are sterile, and reach to the stomatodæum, while the secondaries are incomplete but bear generative organs. I observed a few acontia; cinclides, on the other hand, are wanting.

In conclusion, I might refer to the possibility that *Phellia spinifera* may be only a variety of *Phellia pectinata*. In the sole example from Station 320, the spinose knobs were developed only on the upper part of the bark-like body-wall, and even here not abundantly; so that its appearance is intermediate between the characters of *Phellia pectinata* and *Phellia spinifera*. In spite of this, I have retained the separation of the two species, because the musculature of the oral disc of *Phellia pectinata* does not yield, on further study, the characteristic appearance drawn in Pl. II. fig. 8. In this respect, the transitional form agrees with the type of *Phellia spinifera*.

Family 8, Amphianthidæ, R. Hertwig.

Genus *Amphianthus*, R. Hertwig.

Amphianthus ornatum,* n. sp. (Pl. I. fig. 8).

Body-wall beset with numerous (about 26) longitudinal rows of papillæ; the latter are for the most part recognisable by the naked eye, and are not arranged in transverse series.

Habitat.—(*a*) Station 56, May 29, 1873; depth, 1075 fathoms. One specimen. (*b*) Station 241, June 23, 1875; depth, 2300 fathoms. Three specimens. (*c*) Station 244, June 28, 1875; depth, 2900 fathoms. One specimen.

Dimensions.—Height, 0·2–0·5 cm.; length of the pedal disc, 0·3–2 cm.

The five specimens which I describe under the name of *Amphianthus ornatum* have on the one hand many points of resemblance to *Amphianthus bathybium*, on the other to *Cylista* (*Bunodes*) *minuta*; with the latter they agree in the form of the papillæ, but differ from it in the divergent shape of the body and in characteristics of the family Amphianthidæ, as also in the absence of acontia; with the former, on the other hand, they tally in general habits, but exhibit a divergent condition of the body-wall. *Amphianthus bathybium* possesses small papillæ, recognisable only with the aid of a lens, and arranged in small groups, with a tendency to transverse series. In *Amphianthus ornatum*, however, they are large, and comparatively isolated in position; they form about 20–30 longitudinal rows, which die out sooner or later at some distance from the lower end of the body-wall. The papillæ are not all of one size; indeed, it even happens that rows of larger and smaller alternate.

In the very young specimen from Station 244, only twelve rows of papillæ were present, all most regularly distributed on the periphery of the body, and all of essentially similar structure, since both in the size and number of the papillæ the individual

rows were closely identical. The number of the papillæ varies between six and seven. From this observation it may be inferred that with increasing growth an addition to the rows of papillæ occurs, proportional to the additions to the pairs of mesenteries. In connection with this is the fact that the rows of papillæ correspond to the intramesenterial chambers.

Two examples of the present species were taken from the same locality as the one example of *Amphianthus bathybium*, Station 241. This renders it necessary to weigh the possibility that the differences which have been made of importance, are perhaps only of secondary significance, and that all the specimens may be referred to one species. Owing to the limited material, the question could not well be decided.

From the minuteness of the organism, anatomical investigation could only be effected by means of longitudinal and transverse sections; to this purpose I devoted two complete examples, the one from Station 241, the other from Station 244, besides quadrants of specimens from Stations 241 and 56. It resulted that the papillæ were proved to be solid outgrowths of the body-wall, and, like it, consist of an extremely fibrous mesoglœa. The fibres are generally interlacing, as is for the most part normal among Actiniæ, so that the tissue appears finely granular; they also here and there show a tendency to arrangement into bundles. In transverse sections, therefore, a reticulate figuring appears round the endodermal lining; this can be rendered clearer by staining, when it appears that small branches of the fibrils cross the course of the rest of the fibrils in a longitudinal direction. Similarly, one sees numerous radial fibres also in the peripheral parts of the body-wall, and a corresponding radial striation is thus produced.

The sphincter is completely embedded in the connective-tissue of the body-wall, and consists of small mesoglœal muscle-bundles composed of few, but powerful, fibres. In some places only two or three fibres are united in a bundle, or a single fibre even may run in the connective-tissue. The individual bundles are enclosed in such numbers in the mesoglœa as to be separated from the two epithelial surfaces by only a narrow layer. In transverse section, the muscle in most cases forms a club-shaped figure, being of weak development below and broadening out strongly upwards; this increase in breadth is so considerable that the whole upper end of the body-wall is strongly thickened. Even in the youngest specimens the sphincter was completely formed, and inclosed in the mesoglœa. As it is separated from the endodermal circular musculature by the insertion of a layer of connective-tissue, it seems that in the course of further growth the bundles can only increase by division of the bundles of fibrils.

The musculature of the oral disc and tentacles is purely ectodermal, but very markedly pleated. The number of tentacles corresponds to the number of mesenteries, and this is different in the different individuals investigated. In the youngest specimen from Station 244, the two first cycles were already formed, and of the third traces

seemed to me to be recognisable in that inter-mesenterial chamber which is equidistant from the ends of the transverse and sagittal axes. With this agreed the distribution of the tentacles; they were about equal in number to the mesenteries, and amounted to more than twenty-four, *i.e.* the first three cycles and some tentacles of the fourth were present, and those of the fourth cycle lay at points corresponding to the inter-mesenterial chambers above mentioned. In the other specimens, between forty and forty-eight mesenteries were present in the whole circuit of the body-wall, so that here the fourth cycle was nearly complete. The number of mesenteries was still greater in the angle between pedal disc and body-wall, the point where mesenterial growth is first recognisable in Actiniæ. This part being very transparent, the number could be determined with approximate accuracy, and reached to nearly a hundred.

From the fact that in places the mesenteries were discontinuous in transverse section, I infer the existence of mesenterial stomata. On the other hand, I could not demonstrate acontia; generative organs (testicular follicles) I saw only in one specimen, and, as they were at all points adherent to the mesenteries, I could not determine whether they were present on all mesenteries, or were wanting on the primaries.

Directive septa and siphonoglyphes were distinguishable on all four specimens, but only in two examples, namely the smallest and largest, could I accurately determine the position which agrees with the typical attitude of Amphianthidæ. The sagittal axis of this Actinian is at right angles to the long axis of the body on which it has fixed itself, or, in other words, the lengthening of the animal takes place in the direction of the transverse axis.

With tolerable certainty I can at length assert that only the mesenteries of the first order are complete.

With the sole example of *Amphianthus ornatum* from Station 56 was associated another Amphianthidan, externally so little characterised, that I decided not to describe it. It possessed a smooth body-wall, which was pleated only as the result of contraction; the pedal disc was 1·5 cm. long, and the total height 0·4 cm.

Family 9, Ilyanthidæ, Gosse.

Genus, *Halcampa*, Gosse.

Halcampa kerguelensis,* n. sp. (Pl. II. fig. 5).

Tentacles devoid of longitudinal furrows, pointed; circular muscles of the body-wall weak; retractor muscles of the mesenteries powerfully formed.

Habitat.—(*a*) Station 149 A, Betsy Cove, Kerguelen, January 10, 1874; depth, 25 fathoms. Ten specimens. (*b*) The same locality; 25–30 fathoms. One specimen. (*c*) Station 149 G, off London River, Kerguelen, January 29, 1874; 110 fathoms.

Three specimens. (*d*) Station 149 J, off Cumberland Bay, January 29, 1874; 105 fathoms. Three specimens. (*e*) Station 149 H, off Cumberland Bay; January 29, 1874; 127 fathoms. One specimen.

Dimensions.—Length, 1·5–2·5 cm.; greatest breadth, 0·7–1·0 cm.

On an external inspection I was inclined to identify this species with *Halcampa clavus*, which it strongly resembles. The preparation of tranverse sections, however, caused me to abandon this view, and a more accurate study produced a number of points of divergence, which I will briefly enumerate.

1. The tentacles, though twelve are also present in this species, are essentially longer than in the other, and end in a fine point. The two longitudinal furrows which occur on them in *Halcampa clavus*, can be recognised neither superficially nor in transverse section.

2. The circular muscles of the body-wall are weakly developed; the laminæ which they form are not so striking as in *Halcampa clavus;* and they project into the cœlenteron at greater distances from each other. The sphincter-like enlargement of the circular muscle-layer is wanting.

3. On the stomatodæum the marked projections, which designate the insertions of the mesenteries, are absent.

4. In the mesenteries the muscle-lamina is pleated in a most complicated manner, so that in transverse section it exhibits an abundant arborescence. The centre of the muscle forms a sort of tree (Pl. II. fig. 5), a thin lamina starting outwards from the mesentery, and branching like the top of a tree. This whole region is usually marked off by an indentation from the adjacent parts, the mass of muscle being thus divided into three sections.

Genus, *Halcampella*, Angelo Andres.

Ilyanthidæ with six powerfully developed pairs of mesenteries, but with numerous rudimentary mesenteries, and numerous tentacles.

Halcampella maxima,* n. sp.

Tentacles small, approximately 46; body devoid of longitudinal furrows; its surface partly bark-like, partly somewhat incrusted; the polyp of considerable size.

Habitat.—Station 209, Zebu, Philippine Islands, January 22, 1875; 100 fathoms. Six specimens.

Dimensions.—Length, 8–15 cm.; greatest breadth, 2–3 cm.; breadth at narrowest point (near the pedal disc), 0·4–1·2 cm.

In all the specimens the body is a lax thin-walled sack; its diameter is least at the posterior end, which is stalk-like and rounded off, but anteriorly it bellies out, contracting again in the region of the oral disc. With the exception of the largest, all the

specimens are so contracted that tentacles, oral disc, and upper part of body-wall were all drawn inwards together; in the largest, however, part of the tentacular crown protruded.

The surface of the body-wall is encrusted with sand-grains, so that at first sight I was inclined to take the animal for a *Sphenopus.* The sand-grains are not, however, embedded in the mesoglœa, but adhere to the cuticle of the ectodermal epithelium, so that they can easily be removed by scraping. At the anterior end they are more sparse, and are practically absent on the upper third. This part of the body-wall assumes a different appearance to the rest, being more leathery or bark-like, and traversed by rough longitudinal furrows. The bark-like appearance is produced by the cuticle, which is strongly developed, and of a brownish tint, resembling that of *Phellia pectinata* and *Tealia bunodiformis.* A fairly sharp boundary marks off from the rougher part of the body-wall a strip about 1 cm. wide, which adjoins the oral disc and wreath of tentacles, and which has a completely smooth surface. One can thus, as in *Halcampa clavus*, recognise three regions of the body,—capitulum, scapus, and physa; but only the capitulum is marked off from the rest with any degree of sharpness.

Histologically the body-wall is composed of a strong fibrous connective-tissue. The individual fibres are extremely fine, and are united in great numbers into tracts; they are not so sharply bounded, as, for example, in the connective-tissue of Vertebrata, but, like them, have a curving course. Generally they cross one another and interlace in every direction, and only under the endodermal surface does a longitudinal arrangement preponderate, parallel to the endoderm. Here the fibres stain exceedingly deeply in picrocarmine, while at all other points fine cords alone retain the stain after washing.

The endodermal circular muscle-layer is formed into lamellar pleats, arranged closely like the leaves of a book, and seldom showing arborescence in section. A muscular region specially developed for a sphincter is not present.

The tentacles are small conical stumps, measuring in the contracted condition about 0·5 cm., and devoid of the two longitudinal ridges occurring in *Halcampa clavus.* On the other hand, the terminal pores are obvious, and in many cases are recognisable with the naked eye. The tentacles are arranged in several rows; their number in one case amounted to forty-six, and was perhaps increasing, as I found several small tentacles among the larger. The longitudinal muscle lamella is ectodermal, and but little pleated.

The oral disc is very small, and presents twelve radial ridges, produced at the edge of the mouth into the longitudinal ribs of the stomatodæum; the latter are sharply-angled, with deep furrows between them. A specially differentiated siphonoglyphe is not present. The length of the stomatodæum in the largest example amounts to nearly 2 cm. Correlated with the absence of a siphonoglyphe is that of a stomatodæal cone. The boundary between oral disc and stomatodæum is sharply marked by the lip being elevated into a circular fold.

The radial muscles of the oral disc are ectodermal, and form a slightly pleated layer; a notable point is the presence of small bundles irregularly embedded in the mesoglœa.

The number of mesenteries appears on macroscopic examination to be confined to twelve, set at equal distances on the periphery of the stomatodæum; they are so grouped in pairs according to the muscular distribution that one can distinguish two pairs of directive and four pairs of intermediate mesenteries. They resemble thin veils stretching between body-wall, oral disc, and stomatodæum, unusually delicate, and tearing at the slightest strain; below, they reach nearly to the posterior pole of the body, but are here so weakly developed as to hardly project at all into the cœlenteron.

In these veil-like mesenteries are recognisable, as special thickenings, the following organs:—1, the muscle pennons or retractors; 2, the muscles of the edge; 3, the generative organs; 4, the digestive filaments.

The retractors are powerful swellings about 1–2 mm. wide, which are tolerably sharply bounded, and appear as if glued to one side of the mesentery; they commence at the angle where oral disc and stomatodæum are continuous, and run from this point in a slight curve outwards and downwards to the boundary between the first and second thirds of the body-wall, where they terminate, thus dying out disproportionately soon, far sooner than even in *Halcampa clavus*. Transverse sections exhibit their structure in greater detail; in the region of the muscle the supporting lamina is strongly thickened, and is elevated, together with the muscle-layer resting on it, into lamellæ which are long, thick, and parallel to one another, but which either do not branch at all, or only slightly. An arborescent or bushy appearance is occasionally produced by a ridge of the mesoglœal mesenterial lamina bearing on both sides a complete series of muscular lamellæ. The sharp boundary of the muscular masses is referable to the circumstance that on both sides the pleating of the muscular layer ceases abruptly.

The edge-muscles form a band of tendinous appearance running close along the body-wall, and are most clearly expressed in the posterior parts of the body. Here they constitute nearly the whole of the mesentery, and the mesenterial filament is affixed almost directly to them.

The mesenterial filament is fairly obvious for the first two centimetres below the stomatodæum, and is arranged in a few coils. Afterwards it becomes finer, but is wound into a mass of twisted loops, continuing thus for about the next four centimetres. The contortions then become gradually less marked, till, sooner or later, the whole filament dies out; in one mesentery it could be followed to within two centimetres of the posterior pole. The first section of the filament is trilobate, possessing one glandular and two ciliated lobes; lower down it undergoes, as in other cases, a simplification of structure by the dying out of the ciliated lobes.

Both the glandular and the ciliated lobes are of exceptionally strong development; the continuations of the mesoglœal lamina entering them broaden out in the shape

of a wing, so that an accurately transverse section of the trilobate filament exhibits the mesoglœa in form of a cross, the arms of which are broad and wing-shaped.

The generative organs lie in the thin septum which is intercalated between the retractor and the mesenterial filament, and were male in one specimen investigated, in the other female. The testes are 1·5 cm. long, 0·2 cm. broad, composed of separate follicles which are arranged in about thirteen transverse swellings. At the edge of the organ occur small bodies, recognisable only in transverse sections, which I take to be the first commencements of the follicles; the supporting lamina widens out, enclosing a space in which are included roundish cells (spermatoblasts?), fewer (five) or more numerous according to the size of the cavity. The latter always opens towards the epithelium by a small but obvious pore. The latter would argue, if there were any question here of stages of development of the testis, for its derivation from endoderm; unfortunately, however, the mesenteries were not sufficiently well preserved for a close histological investigation.

In the female organ the conditions were similar; the ova are irregularly scattered in the mesentery as larger or smaller grains; those of fair size project above the surface, while the largest of all stand out markedly beyond its plane, and are connected with the mesentery only by means of a fine pedicle. The pedicle passes into a chorion which surrounds the ovum on all sides, the latter being about 1 mm. in diameter. In this condition the ovum appears to be already in segmentation.

In the mesenteries occur, finally, external stomata; they are oval, about 0·5 cm. long, and occur rather to the outer side of the great mesenterial muscles, on a level with the wreath of tentacles. Whether also internal mesenterial stomata exist just below the oral lip, remains doubtful.

From the type of the true *Halcampæ*, this Actinian diverges in exhibiting a commencement of additional mesenterial cycles, although these are extremely weakly developed. The accessory mesenteries are small projections, which, in the upper part of the body alone, emerge from the angle between body-wall and oral disc; here there occur pairs of mesenteries both of the second and third orders, readily distinguishable by difference of size. Since, as we have seen above, the number of the tentacles also is larger than in the true *Halcampæ*, the genus *Halcampella* leads up to the remaining Ilyanthidæ, and through them to the true Actiniæ.

Halcampella, sp.* (?)

Habitat.—Shallow water; St. Vincent, Cape Verde Islands, July 1873.

To the genus *Halcampella* doubtless belongs another Ilyanthidan with numerous tentacles, although too much mutilated for close investigation or systematic determination. It is to be distinguished from *Halcampella maxima* at once, by the absence of incrustation on the body-wall.

II. Paractiniæ.

Family 10, Sicyonidæ.

Genus *Sicyonis*, R. Hertwig.

Sicyonis elongata,* n. sp.

The animal is elongated, with about 54 tentacular papillæ; the genital mesenteries project into the cœlenteron from between the oral disc and the body-wall.

Habitat.—Station 244, June 28, 1875; 2900 fathoms. One specimen.

Dimensions.—Height, 7 cm.; breadth about 3·5 cm.; diameter of the pedal disc, 2 cm.

The sole specimen at my disposal was so strongly contracted that one could hardly find the entrance to the oral disc. The pedal disc was also exceedingly small, due partially, no doubt, to contraction. Had the specimen, which in other respects also was but poorly preserved, not been so compressed in the packing, it would have had the shape of a long sack sewn up at both ends.

The external appearance of the animal is therefore essentially different from that of *Sicyonis crassa*, the body of which is flattened like a cake; but in the internal structure there is considerable agreement between the two. The sphincter, the muscles of the tentacles and oral disc, the cuticular consistence of the mesoglœa, the differentiation of muscular and genital mesenteries, the enormous folding of the siphonoglyphes, the radial striation of the oral disc, the shape and arrangement of the tentacles, are in both cases identical. I was therefore inclined to regard it as a new specimen of *Sicyonis crassa*, had I not lighted on one distinguishing characteristic of great importance.

The genital mesenteries in *Sicyonis crassa* are thin lamellæ, which bear only the generative organs, and spring in the angle between pedal disc and body-wall; but in this new specimen the muscles are obvious, and are arranged in "muscle-pennons;" the most noteworthy point, however, is, that the genital mesenteries belong to the upper section of the body, lying in the angle between oral disc and body-wall, on the former they reach as far as the oral opening, and on the latter, in the form of slight folds, up to the pedal disc. Mesenterial filaments do not occur on them. Since the specimens of both *Sicyonis crassa* and *Sicyonis elongata* were males, the different position of the mesenteries cannot be due to the difference of sex.

Part of the animal was anatomically investigated with reference to the arrangement of the mesenteries, and part of the body-wall, with the mesenteries in the neighbourhood of the stomatodæum, was utilised for transverse sections. I was able to prove the normal arrangement of the mesenteries in pairs at some points; but at certain spots irregularities occur, owing to the alternation of isolated genital mesenteries

with isolated complete ones. It is probable that, here and there, the one mesentery of a pair is formed, the other arrested. I was compelled to relinquish the determination of the number of the mesenteries, in order to spare the specimen. I counted, however, the number of tentacular papillæ, amounting to fifty-three; some of these, in the neighbourhood of the single siphonoglyphe, were very small. I infer from this that increase of the number of the tentacles was not yet concluded.

III. Edwardsiæ.

Family 11, Edwardsidæ.

Genus *Edwardsia*.

Edwardsia, sp.* (?).

Habitat.—Station 168, July 8, 1874; 1100 fathoms. One specimen.

The sole example of the genus *Edwardsia* which I met with in the Challenger material, and which came from a depth of 1100 fathoms, was so strongly contracted that the capitulum was concealed within the scapus, and in the posterior section was so completely crushed that it was difficult to detect the rounded hinder pole.

The surface is extraordinarily rough and bark-like, probably in consequence of an incrustation of mud on the cuticular layer; at the anterior end the entrance to the mouth is visible, and round it are eight radial furrows, which, owing to the indifferent preservation, could be followed only for a short distance upon the body-wall. The opening is slit-like; the wedge-shaped regions bounded by the furrows at the anterior pole are dissimilar in size, and are so arranged that the broadest is at one end of the slit, the smallest at the other, while the remaining six are symmetrically arranged right and left. At the posterior end of the animal, only seven of these furrows, which correspond to the mesenterial insertions, can be recognised.

I attempted to investigate the structure further by means of transverse sections, but was reluctantly forced to the conviction that nothing remained of the mesenteries and stomatodæum.

IV. Zoantheæ.

As the result of researches instituted by G. von Koch and myself, I have in my former Report separated from the hexamerous Actiniæ, the sharply marked group of the Zoantheæ, and have described as their representatives the genera *Sphenopus*, *Zoanthus*, and *Epizoanthus*.

I conceived it to be eminently inappropriate that such discordance should exist in the nomenclature of the individual species and genera of Zoantheæ, a discordance

referable chiefly to the fact that the forms described had been quite insufficiently studied, and that consequently the systematic characters had been referred to points of secondary moment only. In this condition of affairs no alteration has been effected by the monograph of Angelo Andres; the great abundance of forms cannot be compressed, as he has attempted to compress them, into the three genera, *Zoanthus*, *Palythoa*, and *Sphenopus* (the genera *Verrillia*, *Bergia*, and *Antinedia* having but a doubtful position, so long as we possess such scanty information about them as at present).

I have therefore requested Dr. Erdmann, one of my students in Bonn, to undertake a revision of the Zoantheæ with reference to the following important anatomical characters:—(1) condition of the cœnenchyme; (2) arrangement of the mesenteries; (3) structure of the sphincter; (4) condition of the integument; (5) colony-formation. His conclusions are as follows:—The Zoantheæ may live solitary (Sphenopidæ), or may form colonies (Zoanthidæ); in the latter case the cœnenchyme may either consist of basal stolons more or less branching, sometimes even anastomosing, or of a connecting lamella, or of a mass which unites the polyps almost for their whole height. The integument either consists merely of an epithelium and cuticle, or else there occur on it foreign bodies, which penetrate the mesoglœa of the body-wall, and more or less fill it. In the arrangement of the mesenteries two points are of importance: (1) that the pairs of mesenteries, with the exception of the directives, consist of a macro- and a micro-mesentery; (2) that a dorsal and a ventral zone of mesenteries must be distinguished. The two zones may approximate either with small (Microtype) or with large mesenteries (Macrotype). Finally, the sphincter exhibits three modes of formation; it may be (1) endodermal; (2) mesoglœal; (3) it may be mesoglœal, but distinguished by a muscle-free region into upper and lower portions.

With reference to the points above mentioned, Erdmann has distinguished five genera in the colonial Zoanthidæ, the characteristics of which may be followed without further comment in the accompanying table:—

Genus.	Mesenterial arrangement.	Sphincter.	Cœnenchyme.	Integument.	Generative organs.
Zoanthus.	Microtypal.	Mesodermal, duplex.	Stolonar.	Soft.	Hermaphrodite.
Mammilifera.	Microtypal.	Mesodermal, simple.	Stolon-like, with a tendency to form lamellæ.	Soft.	(?)
Epizoanthus.	Macrotypal.	Mesodermal, simple.	Connective, lamellar.	Incrusted.	Diœcious.
Palythoa.	Macrotypal.	Endodermal.	Resembling a ribbon or tongue.	Incrusted.	Diœcious.
Corticifera.	Microtypal.	Mesodermal, simple.	Polyps sunk in the cœnenchyme to their upper ends.	Incrusted.	(?)

The material which I was able to place at Dr. Erdmann's disposal was derived partly from the Bonn Museum, partly from the Triton expedition, but chiefly from the Challenger collection. For the descriptions of the Challenger Zoantheæ I give here short extracts from his Memoir,[1] for the accuracy of which I can vouch, as the whole investigation was carried out under my direction. I have achieved, what he omitted, in identifying as far as possible the forms obtained with species previously described, and, where that was impossible, have introduced new names, and have reduced the diagnoses of species to shorter and more precise terms.

Family 12, Zoanthidæ.

Genus *Zoanthus*, Cuvier (*pro parte*).

Integument not incrusted; cœnenchyme stolonar, with an occasional tendency to lamellar extension; sphincter differentiated into upper and lower sections; mesenteries arranged on the microtype.

Zoanthus danæ (?), Le Conte (Pl. I. fig. 1).

Polyps with fleshy body-wall, the larger borne on a stalk-like extension, and arranged closely together on reticulately branching stolons; approximately fifty tentacles arranged in two cycles.

Habitat.—Bermuda Islands; shallow water.

Dimensions.—Of the individual polyps—height, 0·5–2·5 cm.; breadth, 0·3–0·5 cm.

This animal, which I refer with considerable reserve to *Zoanthus danæ*, is identical with the *Zoanthus* which I have already described. To that description I can add the following points, based on Erdmann's researches:—

1. The colony grows on a foundation of rock in such a manner that the upper ends of all the polyps lie in the same plane. As the foundation is irregular, the individual polyps must be of unequal lengths, a result of which is that those animals which correspond to hollows in the foundation are produced posteriorly into a kind of stalk, distinguished from the body proper by a constriction, and by the thinner consistence of the body-wall.

2. A peculiar attachment of the cuticle to the body-wall, and one perhaps more widely distributed among the Zoantheæ, is effected by mesoglœal processes which perforate the epithelium and are inserted on the cuticle.

3. The colony investigated by Erdmann was sexually mature; ova and testicular follicles occurred in the same mesentery.

[1] Erdmann, Ueber einige neue Zoantheen. Ein Beitrag zur anatomischen und systematischen Kenntniss der Actinien, *Jenaische Zeitschr.*, Bd. xix. pp. 430–488, pls. iv. v.

Zoanthus confertus,* Verrill (Pl. I. fig. 12).

Polyps with thin transparent body-wall, so closely packed as to be polygonally flattened.

Habitat.—Simon's Bay, Cape of Good Hope ; 10–20 fathoms.

Dimensions.—Of the individual polyps—height, 0·6–0·8 cm. ; breadth, 0·3–0·4 cm.

The species is in general structure very close to the preceding, but differs in the thin consistence of the body-wall, through which may be seen the mesenteries, and in the compact arrangement of the polyps. The latter being consequently compressed polyhedrally, a character of importance is afforded for the species, which is further marked off by the transparence and delicacy of the body-wall.

Genus *Epizoanthus*, Verrill.

Integument incrusted, cœnenchyme (mostly ?) lamellar; sphincter simple, mesoglœal ; mesenteries arranged on the macrotype ; colonies (mainly ?) parasitic.

Epizoanthus thalamophilus,* n. sp. (Pl. I. fig. 3 ; Pl. IV. figs. 7, 8).

Incrustation scanty, exclusively composed of Foraminiferal shells, which are arranged on the individual polyps into 15–20 longitudinal rows, bifurcating downwards ; body-wall transparent ; tentacles 30–40, very long, and arranged in two rows.

Habitat.—Station 299, December 14, 1875 ; 2160 fathoms ; on Gastropod shells.

Dimensions.—Height of the contracted individuals, 0·2–1·3 cm. ; diameter at the base, 0·9–1·5 cm.

"The colony of seventeen individuals has settled on a deserted *Fusus* shell about 8 cm. long. The polyps are principally situated on the back of the shell, and only the five young individuals at its apex are arranged in a whorl round it. The region round the aperture of the shell is free from polyps ; they rise with elliptical bases from a common cœnenchyme, and arch upwards like a dome. The largest specimens have a base of 10–15 mm. in diameter, and are 13 mm. high ; but we find every transition to the smallest specimens, which appear as flat elongated projections with a base of 5–9 mm., and a height of 1·5–3 mm. The cœnenchyme is a continuous sheet, 0·3–0·5 mm. in thickness, which covers the shell as far as the colony reaches. Towards its termination it becomes constantly thinner and more transparent, till it ends as a very delicate pellicle, which may be easily rubbed off. All the polyps were in a highly contracted condition ; and at the dome-shaped summit lies, on a prominence which is bounded by a circular furrow, the entrance to the interior ; it is hardly recognisable as an opening, and is formed by the indrawn parts of the body-wall. The latter is of slight thickness, so that the

mesenteries may be seen through it as clear stripes. In the external zone of its mesoglœa lie the deposits above mentioned, consisting exclusively of Foraminiferal skeletons. They are evenly distributed over the cœnenchyme ; but on the body-wall are ranged in a most regular and elegant manner, the following facts being recognisable with the aid of a lens. From the apex outwards run, in a well-grown individual, fifteen to twenty looping rows of Foraminifera in clear elevated lines. Where the body-wall bends downwards at right angles, each row bifurcates, and each branch so produced runs downwards on the body-wall in a straight line ; a single row of Foraminifera is thus situated over each mesentery, the insertion of the latter being externally clearly recognisable, owing to the thinness of the wall. While therefore, from the apex of the polyp outwards, the ridges agree in number with the pairs of mesenteries, in the lower part of the body-wall there are present as many rows of shells as there are individual mesenteries. Towards the base these become less plain, so that at the lowest part of the polyps, as on the cœnenchyme, the Foraminiferal coating is evenly distributed all over" (Erdmann). The rows of shells are continued on to that region of the body-wall which has been drawn inwards ; and their arrangement can here be only understood by referring to the point of transition from body-wall into oral disc. This occurs along an undulating curve, since at one point the oral disc with its outer circlet of tentacles, at another the body-wall with its rows of shells, projects the farthest. A horizontal section therefore, through the region under discussion, meets alternately with rows of Foraminifera and the origins of tentacles (Pl. IV. fig. 8). Further, at the point of junction, the body-wall forms a strongly projecting fold in which lies the greater part of the sphincter (Pl. IV. fig. 7). The horizontal section represented in fig. 8 exhibits this fold on the inner side, while on the outer lie the body-wall and oral disc, united by mesenteries.

The fold of the body-wall bears, on both sides, rows of Foraminiferal shells, supported on ridge-like processes of the body-wall, and appearing therefore in transverse section as coronets ; they are, as we learn from longitudinal sections, discontinuous at the free edge of the fold, so that the outer and inner rows of shells do not pass into each other.

The sphincter embedded in the fold of the body-wall is mesoglœal and simple, and forms here an evenly distributed complex mass of muscle-bundles, the latter being variously shaped. It also overlaps a small strip of that region of the body-wall which is not drawn inwards.

The tentacles are, as in other cases, in two alternating circlets, and are in part produced into long pointed filaments, in part contracted into short stumps. Their muscles are ectodermal and slightly pleated ; the mesoglœal supporting lamina lying at the base of the pleats sends processes into the epithelium.

The stomatodæum is oval, and the siphonoglyphe only slightly expressed.

The number of mesenteries varied in the three specimens investigated between twenty-eight and thirty-six, according to their size. The dorsal and ventral zones of mesenteries approximate always with macromesenteries.

No channel filled with cells is present at the bases of the mesenteries; the muscle-pennons indistinct; the generative organs so abundantly developed as to fill the greater part of the cœlenteron. These latter occur only on the macromesenteries, and consisted of testicular follicles in the three specimens studied.

The cœnenchyme is extremely thin, and possesses internally smooth connecting-tubes lined by endoderm; on the upper surface Foraminiferal shells are sparsely embedded; while on the other side, which covers the Gastropod shell, these are entirely absent.

The name *thalamophilus* was chosen with reference to Thalamophora and Polythalamia, names which have been applied to the Foraminifera.

Epizoanthus stellaris,* n. sp. (Pl. I. fig. 4).

"Polyps of inconsiderable height, nearly saucer-shaped; body-wall vertical at the sides, but strongly flattened above; on its horizontal upper surface are numerous radial ridges, separated by furrows, 15–20 in the adult animal; colour of the colony dark greyish-brown; deposits very various."

Habitat.—Station 202, off Samboangan, Philippine Islands.

Dimensions.—Of the individual polyps—height, 0·05–0·4 cm.; diameter, 0·15–0·7 cm.

"Of this species I possess a colony, covering the rooting spicules of a *Hyalonema* for a distance of about 14 cm., and consisting of about 100 individuals. The cœnenchyme forms a tube open at both ends, and surrounds like a sheath the bundle of spicules, the latter being about 5 mm. thick. The individuals spring from it at longer or shorter intervals by an elliptical base, measuring in the largest polyps (3–4 mm. high) about 5–7 mm. in diameter. From these to the smallest, which hardly project above the cœnenchyme, and are 1·5–3 mm. broad, by 0·5–1 mm. high, every transition is found. All the animals are strongly contracted; on the strongly flattened, discoidal, horizontal surface of the body-wall may be dimly seen the entrance to the interior by a circular pit. From this point outwards radiate over the surface of an adult specimen, about 15–20 ridges separated by furrows.

"The colour of the colony is a dirty dark-grey. The body-wall is of considerable thickness, caused by the strongly developed mesoglœa. The exterior surface of the latter is charged with various deposits, consisting of irregular grains of sand and lime, sponge spicules of very varied origin, and finally of the small dark crystalline bodies which cause the dark tint of the colony. These deposits occur in additional quantity on the radial ridges before mentioned. They are continued inwards as elevated ridges over the edge of the covering fold without a break, and run even further, on the inner

face of the indrawn part of the body-wall. Sections through the upper region of the polyp yield appearances similar to those described under the preceding species, though, owing to the abundant and various deposits enclosed, they are not so regular and elegant.

"In those inner parts of the mesoglœa which are free from adventitious accretions there lie embedded in the homogeneous matrix—1. fine radial fibres, penetrating the whole thickness of the soft mesoglœa, provided here and there with nuclei; 2. round mesoglœa-cells containing a large nucleus; 3. round or oval spaces packed with cells. Hertwig, who has observed similar structures in the *Epizoanthus parasiticus* described by him, conjectures that these oval cell-islets are produced only by indifferent preservation, and result from the breaking down of a system of anastomosing cords, such as the mesoglœa of *Zoanthus* exhibits. I [Erdmann] am inclined to regard these roundish heaps of cells as primary structures, like the canals of *Zoanthus*, since I have been able to recognise them in almost all my species of *Epizoanthus*, which were without exception in a very good state of preservation. As to their origin I have no data; but there is no reason why they should not be referred to an ectodermal origin as well as the cell-canals of *Zoanthus*, the derivation of which from ectoderm is indisputable; besides, many of these cell-islets clearly exhibit an elongate outline, with here and there even a slight tendency to branch, by which an external approximation to *Zoanthus* is effected.

"The mesoglœa of the mesentery is well developed, and on its inner edge is thickened like a club. The micromesenteries project only slightly into the interior, but, like the macromesenteries, clearly present marked muscle-pennons. On these mesenteries there springs on the side opposite to the muscle-pennons a mesoglœal lamella, which is considerably elongated in order to carry the generative organs and to form, centrally to these, the mesenterial filaments. The former are present in considerable numbers; and, being cut more or less superficially owing to the contorted course of the mesentery, may be recognised in transverse section as roundish balls enveloped in a thin mesoglœal lamella, pressed against the body-wall and generally filling the adjacent chamber. All the specimens which I investigated were female, the generative balls consisting of a large number of ova closely appressed together, but separated by a fine mesoglœa lamina.

"The body-wall is deeply drawn inwards, and conceals in this region a strongly built sphincter, which has the shape described for the preceding species, but which is distinguished by a greater complication in the branching of the bundles of fibrillæ.

"The stomatodæum is oval, with a clearly defined siphonoglyphe. The ensheathing cœnenchyme measures 1–1·3 mm. in thickness; in its interior run longitudinally numerous connecting tubes. The mesoglœa carries on its surface foreign deposits of the same character and quantity as those on the body-wall, but the inner face, which lies

on the foundation, is completely free from incrustation. The soft mesoglœa of the cœnenchyme is, with reference to histological differentiation, in the same relation to the body-wall as it is in *Zoanthus*, since here also, in addition to the other points of marked agreement, the nucleated fibres are supplanted by mesoglœal cells.

"With a view to observing the mesenterial arrangement, I studied two examples, one of medium size, and one fully grown; both exhibit the regular macrotype. In the younger specimen occurred a symmetrical arrangement of the pairs of mesenteries; of these there were sixteen, seven being regularly distributed on each side of the directives. The other polyp possessed nineteen pairs, of which nine were situated on the one side, and eight on the other."

Epizoanthus elongatus,* n. sp. (Pl. I. fig. 2).

"The individual polyps form elongated cylindrical tubes, the body-wall is flattened above, with a marked indentation, but terminates without radial furrows; colour of the colony a yellowish-grey."

Habitat.—Station 322, off Monte Video; February 26, 1876; 21 fathoms.

Dimensions.—Height of the polyps, 0·05–1·0 cm.; breadth, 0·15–0·4 cm.

"This species can only be externally distinguished from the preceding. The colony is 10 cm. high, consisting of about 100 individuals, and lives on a bundle of the siliceous threads of a *Hyalonema*, about 3 mm. only in thickness. The largest polyps are long cylindrical tubes, about 8–10 mm. high and 3–4 mm. broad; in their neighbourhood occur gradations to the youngest buds, which are small warts projecting from the cœnenchyme, of 0·5–2 mm. in height, 1·5–2·5 mm. in breadth. All the animals are in a state of the most marked contraction; the horizontal upper surface of the body-wall is more or less flattened, and exhibits a circular indentation. This part of the body-wall is entirely free from radial ridges and furrows. The colour of the colony is a greyish-yellow.

"The body-wall is thinner than in the preceding species, and possesses in its outer zone the same deposits, though in smaller quantity. The remaining anatomical and histological relations agree closely with those of the former species, but it is important to observe that the sphincter is less strongly developed. The body-wall is drawn inwards less deeply; its sphincter is in transverse section correspondingly short, but curved, and pointed at both ends. The generative organs consisted of ova in the five specimens investigated."

Epizoanthus cancrisocius,* Studer (Pl. I. fig. 15).

Colony much incrusted, and consequently so brittle as to break readily in pieces; individual polyps slim, body-wall at the upper end bent outwards in the contracted

condition into a plate-like expansion, from the indented centre of which run 15–20 furrows towards the thickened edge.

Habitat.—Station 49, May 20, 1873; 83 fathoms, upon a Gastropod shell tenanted by a *Pagurus*, the shell entirely dissolved away by the cœnenchyme.

Dimensions.—Length of the polyp, 0·6–1·0 cm.; breadth, 0·3–0·5 cm.; colour, greyish-yellow.

"This species forms a colony of eleven individuals, on a shell some 2·0 cm. high. The calcareous substance of the latter is completely absorbed, and at all points replaced by the cœnenchyme, the latter having obviously taken its place, while preserving its external form. Only the anterior side of this cœnenchymatous structure, *i.e.* the part directed forwards in movement of the Crustacean, possesses polyps; the free posterior side allows the coils of the former Gastropod shell to be clearly recognised. Of the eleven individuals, eight large mature polyps occupy the edge of that side which is directed anteriorly in the movement of the crab. They form long cylindrical tubes, 6–10 mm. high and 3–5 mm. broad. In the median space which they bound, stand three very young polyps, projecting as vertical cylindrical warts from the cœnenchyme, with height and breadth alike of 1·5–2 mm. One may remark that the large polyps bend forwards, *i.e.* their oral discs face upwards, in the direction corresponding to the locomotion of the *Pagurus*, so that they are most favourably placed for the reception of the food matters which stream against them. Owing to the curving just mentioned, the large polyps are above strongly compressed laterally.

"The whole colony has a rough shagreen-like exterior, of a grey colour. The otherwise smooth body-wall forms above a horizontal plate, which not only projects like the capital of a column over the vertical part, but has also a characteristic sculpture, and the appearance of a plate with raised edges and indented centre; in the middle of the latter lies the entrance to the interior, which is slit-like, corresponds to the lateral compression, and is always recognisable as an obvious opening. From this median point outwards radiate over the plate-like surface 15–20 radial furrows, which are continued outwards for a short distance over the marginal thickening, appearing on it as deep notches.

"When a polyp is opened with scissors, one remarks that the mesenteries run down the whole length of the body-wall, but do not pass over on to the horizontal floor of the cœlenteron. In the lowest parts of the polyp, the mesenteries are visible as slightly projecting ridges, striking the eye by their clear colouring; at about one-fourth of the total height, the macromesenteries form filaments; these are yellowish-white contorted coils, which completely obscure the micromesenteries. One can without damage remove the mesenteries from the body-wall, and study them independently. The supporting lamina of the mesenteries is very thin, and runs simply to the base without any excavation; the mesenterial filaments are of the customary

structure. I have been unable to detect generative organs in any specimen investigated.

"Owing to the abundant incrustation, the body-wall becomes as hard and brittle as stone, and does not permit therefore of investigation by means of sections. In this case therefore, and in the remaining forms with similarly strong incrustation, I made use of the method of grinding tested and recommended by G. v. Koch in his researches on *Tubipora*.

"The body-wall is of considerable thickness; its mesoglœa exhibits a structure very different from the remaining species of *Epizoanthus*, as being penetrated by deposits throughout its whole depth. These deposits consist of particles of sand with irregular angles, and are set in a strong circular fence, reducing the mesoglœa to thin lamellæ; but there persists a very narrow internal lamella bounding the endoderm all round. In the homogeneous mesoglœa-lamellæ are situated roundish cells which give off fine radiating processes, and fine fibres provided with nuclei; the presence of the cell-heaps, which are to be met with in the remaining species of *Epizoanthus*, I was unable to demonstrate in this case. A transverse section through the wall of the shell exhibits a similar condition in the cœnenchyme. This latter is also of considerable thickness, and is internally traversed by the large endodermal tubes which connect the various cœlentera together.

"The body-wall is, as has been already mentioned, bent above at a sharp angle, thus forming a plate-like surface. In contrast to the remaining members of the genus, where it turns deeply inwards vertically, it is here only slightly invaginated, a difference resulting from the slighter development of the sphincter. The latter commences to a certain extent on the horizontal part of the body-wall, and then thickens gradually into a truncated muscular mass, which appears fusiform in section, and is only slightly curved inwards. It lies enclosed in the innermost lamella of mesoglœa; the latter is thus much thickened, and is free from adventitious deposits. The sphincter is on both sides bounded by a layer of mesoglœa, which extends inwards to the commencement of the oral disc, is charged with the usual accretions, and is a direct continuation of the outer sandy layer."

So much for the anatomical description given by Erdmann, which sufficiently proves that *Epizoanthus cancrisocius* must be separated systematically from *Epizoanthus parasiticus*, the latter possessing larger and coarser polyps and far less incrustation. I have identified the animal with the *Epizoanthus cancrisocius* of Studer, as he records for his specimens similar dimensions, and a marked incrustation, at least for the basal membrane.[1] In other points his description is not sufficiently exhaustive, and this is still more true of Gray's account.[2] Only the statement of the latter that the large

[1] *Monatsber. d. k. Akad. d. Wiss. Berlin*, 1878, p. 547.
[2] *Proc. Zool. Soc. Lond.* 1867, p. 237.

polyps break up easily, and the reference to a figure of Gosse's which recalls our *Epizoanthus cancrisocius*, make it probable that his *Epizoanthus papillosus* and the *Epizoanthus cancrisocius* are identical.

Erdmann refers it in his Memoir to the expedition of H.M.S. "Triton." I find, however, his specimen in a bottle from the Challenger collection, with the label given above; some mistake must therefore have occurred in his manuscript.

Genus *Corticifera*, Lesueur.

Cœnenchyme extending from the base upwards between the individual polyps, and uniting them together almost as far as the upper edge of the body-wall; integument incrusted; sphincter mesoglœal; mesenteries arranged on the microtype.

On the above diagnosis I may remark that, on the body-wall of each polyp may be distinguished two regions, the one surrounded by cœnenchyme, the other projecting freely above it. When the animal contracts, the latter is drawn inwards to the level of the cœnenchyme as in Madreporaria; it partly serves to close over the anterior end, and partly is invaginated inwards. A colony in contraction consequently forms a crust-like covering, in which the individuals are only indistinctly marked off from each other.

Corticifera lutea,* Quoy and Gaimard (Pl. I. fig. 6).

Individual polyps marked off by fairly obvious stripes on the cœnenchyme, and recognisable as annular ridges on the common surface of the colony; they differ but little from each other in size.

Habitat.—Bermuda, June 1873; smooth water.

Dimensions.—Height, 1 cm.; breadth, 0·4–0·5 cm.; colour, yellowish-white.

"The colony at my disposal consists of a flat, quadrangular, crust-like structure, about 16 cm. long and 7 cm. broad. It does not present a complete whole, but is merely a piece torn off from a larger mass, carrying about 400 individuals; the latter reach a height of 10–15 mm., and are in diameter 4–5 mm. It must be insisted that this external height of the polyps in no way corresponds to the internal, since the cœnenchyme forms on the underside so thick an investment that of the total height only about two-thirds belong to the cœlenteron, the other third to the cœnenchymatous layer beneath. All the individuals are strongly contracted, and the body-wall is drawn deeply inwards. The edge of the body-wall projects above the general surface as an annular depressed ridge, in the centre of which lies, always clearly open, the aperture to the interior. At the unmutilated edge the individuals stand out as slight swellings.

"In that part of the cœnenchyme which borders on the ectoderm, are present numerous accretions, producing a firm pellicle. The main bulk of the incrustation consists of irregularly-shaped calcareous bodies; besides these occur more sparingly

Foraminiferal and Radiolarian skeletons, and finally, numerous sponge-spicules of various kinds. In the cœnenchyme between the polyps, the accretions are present only in small quantity, and fill here simple scattered cavities, which may be recognised after decalcification as wide lacunæ. The rest of the cœnenchyme is soft; and in its homogeneous matrix we meet with large canals, lined by pigmented epithelium and traversing the cœnenchyme in every direction; they are especially numerous in the lower cœnenchymatous investment, which consequently presents a reticulate spongy texture. As appears from longitudinal sections, these canals are direct continuations of the cœlenteron from the base of the polyp outwards, and extend from this point upwards through the whole of the cœnenchyme; they may consequently be homologised with the endodermal connecting tubes to be found in all Zoanthidæ. The mesoglœa of the cœnenchyme exhibits also numerous roundish cell-islets lined by epithelium, in which we may perceive the origin of such ectodermal cell-heaps as have been described for *Epizoanthus*. The whole of the endodermal epithelium is pigmented by dark granules, as are also the large endodermal connecting-tubes. On the other hand, the roundish cell-aggregations just mentioned are free from pigment granules; this difference of condition affords an indirect proof that the latter are by no means of endodermal origin, but are purely ectodermal structures. Finally, the soft cœnenchyme exhibits fine nucleated fibres starting from the endoderm, and, as is usual, numerous mesoglœal cells provided with fine processes.

"The main bulk of the whole colony is to be regarded as cœnenchyme; the individual polyps consist merely of a mesoglœal cylinder lined internally by endoderm, of moderate thickness and homogeneous consistence. The supporting lamina of the mesenteries is of similarly weak development. Below, the latter enclose a canal filled with cells, which in the case of the macromesenteries is frequently divided up by cross anastomoses. The muscle-pennons are well developed, and appear, especially in the larger mesenteries, as branching processes, which extend over a wide stretch of the mesentery. Nothing of interest can be said about the mesenterial filaments. In none of the specimens investigated could I find generative organs. The stomatodæum is pear-shaped in section, with a well-marked siphonoglyphe."

The sphincter is mesodermal, simple, and only slightly developed. It begins early, as a narrow strip, in that part of the body-wall which is drawn horizontally inwards, and extends without any thickening to the edge of the invaginated part. The number of the mesenteries, which are arranged on the microtype, varied in five individuals between thirty-four and forty.

Corticifera tuberculosa,* Klunzinger (Pl. I. fig. 5).

Individuals closely appressed together and flattened polygonally, generally separated by a deep furrow, and of very dissimilar sizes, so that the surface of the contracted

colony appears to be irregularly covered with knobs. These knobs exhibit radial furrows which run outwards from the indistinct opening.

Habitat.—Simon's Bay, Cape of Good Hope; 10–20 fathoms.

Dimensions.—0·6–0·8 cm. in height; diameter, 0·2–0·5 cm.

Colour.—Brownish.

The small colony of about forty individuals differs essentially from the above described *Corticifera lutea* in its external appearance. From the small development of cœnenchyme, it results that the individual polyps press closely on one another, and frequently become polyhedrally, generally hexagonally, flattened. They are separated by deep grooves on the surface, which, at few points only, become shallower or disappear altogether. The absence of the groove between two polyps possibly signifies a genetic dependence, the one having arisen by gemmation from the other; and smaller individuals are frequently adjunct to the larger polyps in this fashion.

The individuals of the colony are of most varying size; from the large dome-shaped convex animals with a diameter of 0·6 mm. those of intermediate size lead to the smaller, which measure only 0·1 mm. in the one direction and 0·2 mm. in the other. Since the surface therefore exhibits smaller and larger knobs, I refer the species to the *Palythoa tuberculosa* of Klunzinger, and have therefore retained the well-chosen specific name.

In length there is but little difference between the larger and smaller animals, the former measuring 0·6 cm., the latter 0·4 cm. As they all diminish downwards in a wedge-shape, the lower side of the colony is so much narrower that the polyps on the edge are nearly horizontal.

All the polyps are so strongly contracted that the entrance to the interior is recognisable only as an indistinct indentation, from which radiate outwards numerous shallow furrows.

With reference to the finer anatomy, what has been said for *Corticifera lutea* holds good in this species. In the two specimens investigated there were respectively thirty-four and thirty-six mesenteries, which followed the microtype.

Genus *Palythoa*, Lamouroux.

Integument strongly incrusted; cœnenchyme little developed, ribbon- or tongue-like; mesenterial arrangement on the the macrotype; sphincter endodermal.

Palythoa anguicoma,* Norman (Pl. I. fig. 7).

Incrustation superficial, so that a thick layer of mesoglœa remains free of deposit; cœnenchyme tongue-shaped; individuals, when in a contracted condition, long, with a terminal capitular enlargement, on which run 15–20 radial furrows.

Habitat.—Station 135 A, off Inaccessible Island; October 16, 1873; 60–90 fathoms; hard ground, shells, and gravel.

Dimensions.—Height of the polyps, 0·4–0·8 cm.; breadth, 0·2–0·4 cm.

Colour.—Brownish-yellow.

"From the material at my disposal, which appears to have been carelessly detached, the general form of the present species cannot with certainty be inferred. The greater part of it consists of single individuals, in which one can recognise the forcible detachment from the colony. One group, which to all appearance represents a complete and intact colony, is composed of four individuals; they are situated, in a row and at short intervals, on a thin cœnenchyme which is extended like a ribbon; their dimensions are 4–8 mm. high by 2·5–4 mm. broad. All the polyps are strongly contracted; the body-wall forms above, in this condition, an obliquely-angled ridge projecting outwards; its upper surface presents an elevation, rendered obvious by a circular furrow, in the centre of which the aperture to the interior is recognisable. From the middle of this upper surface radiate outwards 15–20 furrows, which are continued over the projecting ridge on to the vertical body-wall, where they then flatten out. The colour of the polyps is a dirty yellow.

"The integument is furnished with accretions, and exhibits a rough shagreen-like exterior. On rubbing away the thin sandy layer, there remains the thinner soft part of the mesoglœa, which is excellently fitted for the preparation of longitudinal and transverse sections with a razor.

"The soft mesoglœa is of considerable thickness, and consists of a homogeneous matrix, in which come into view the large number of cavities charged with cells. These may be simple, *i.e.* preserve their roundish or elliptical outline, or, as in most cases, may branch to form a system of anastomosing canals which entirely recall *Zoanthus*. Below the endoderm such a canal runs in an almost unbroken ring through the whole of the body-wall; it lies so close under the epithelium as to be separated from it only by a narrow lamella of homogeneous matrix. Its diameter is not constant throughout its whole circuit, but is frequently constricted, and occasionally such constriction produces an actual discontinuity. It is further of importance that the canal invariably presents a considerable hollow expansion under each mesenterial insertion. At many points can be demonstrated a communication between the smaller branching cell-canals and this large ring-canal, the latter being at such places apparently expanded into a kind of funnel. Further, there are found in the mesoglœa numerous mesoglœal cells, giving off fine processes; and, finally, delicate nucleated fibres, the course of which, however, is here not radial, but in the main circular.

"The structure of the cœnenchyme agrees in all respects with that of the body-wall, except for the fact that it possesses endodermal connecting tubes.

"The mesoglœa of the mesenteries is strongly constructed, and on it can be recognised well-developed muscle-pennons. The generative organs, borne in the supporting lamina, consisted of ova in the individual which I investigated. The mesenterial filaments are of the customary structure.

"The mesenterial arrangement is to be referred to the macrotype. The specimen investigated possessed thirty-six mesenteries, of which five pairs pertained to the dorsal zone, and thirteen pairs to the ventral; in the latter zone were ranged regularly, on each side of the directives, six pairs, consisting of a macro- and a micro-mesentery.

"The body-wall is drawn inwards at a right angle; on the inner side of this region a definite endodermal sphincter may be recognised. The pleatings of the endodermal muscle-lamina are more clearly marked than in *Palythoa axinellæ;* and produce on the mesoglœa prominent antler-like prongs. The accretions are continued on to the indrawn region of the body-wall, but die out at its lower edge, where the oral disc commences."

The identity of this animal with *Palythoa anguicoma* is doubtful, as Norman, who created the species, gave no figure of it. I was influenced by the circumstance that eighteen rough radial furrows are ascribed to this form; besides which the incrustation on it should be only superficial.

Palythoa, sp.* (?)

Habitat.—(*a*) Station 135 A, off Inaccessible Island, October 16, 1873; 60–90 fathoms. (*b*) Station 135 C, off Nightingale Island, October 17, 1873; 100–150 fathoms.

In the same bottle with *Palythoa anguicoma* was another species of *Palythoa*, which recurred in a second tube, the contents of which were dredged a day later than the first, and at a greater depth. The specimens in question could easily be distinguished from individuals of *Palythoa anguicoma* by containing black particles of hornblende. Erdmann attempts to separate the two species, and gives the following description:—

"In this species also the larger part of the material consists of individuals torn away from the colony; one colony, which was undoubtedly not mutilated, was represented by three individuals, ranged behind one another on a ribbon-like cœnenchyme. Externally this species differs from the preceding in colour only, which is in this case a dull grey-brown; besides this, from the greater firmness and unevenness of the body-wall, it may be recognised that the mass of accretions is greater. The body-wall presents, in contrast to the former species in which the relations are reversed, a considerable zone charged with accretions, opposed to a slightly-developed soft zone of mesoglœa. In the latter there passes close under the endoderm a cell-canal, frequently constricted, but rarely interrupted; external to this follow immediately the accessory deposits, so that of the numerous canals and spaces observed in the preceding species only a few roundish cell-islets are preserved.

Palythoa (?) sp.* (?)

Habitat.—Station 299, west of Valparaiso, December 14, 1875; 2160 fathoms.

I found a small Actinia, labelled "Actinia on nodule," which had settled on a piece of pumice near an Ascidian. The animal, being incrusted with sand particles, probably belongs to the *Palythoæ*, but its minuteness and the sandy incrustation forbade a detailed study. The body, not so much as 1 mm. high, was flattened into a disc 5 mm. broad. The number of mesenteries which, as in the Zoantheæ, were very regularly arranged, amounted to thirty-two.

Family 13, Sphenopidæ.

Genus *Sphenopus*, Steenstrup.

*Sphenopus pedunculatus,** n. sp. (Pl. I. fig. 11).

Body marked off into an upper swollen trunk, an elongate narrow foot, and a broad sole-like (?) "clasping-disc;" from the apex run, over the upper part of the trunk, about 10–12 indistinct rough furrows.

Habitat.—Station 203, off Panay, Philippine Islands, October 31, 1874; 12–20 fathoms. Three specimens.

Dimensions.—Length, 2·4–3·2 cm.; breadth, 2–2·4 cm.

Colour.—Grey.

"This species differ in many respects from the already known *Sphenopus marsupialis* (Steenstr.) and *Sphenopus arenaceus* (Hertw.). The fully-grown animal permits of an external differentiation into three regions. The most obvious part of such a polyp is formed by the upper bladder-like 'body' (Pl. I. fig. 11), which conceals within itself the organs of nutrition and reproduction. On it is marked off, by a more or less obvious cross-furrow, a hood-shaped anterior region, sculptured by coarse radial furrows. The body passes into a long narrow 'foot,' from which it is sharply defined by a marked furrow, and finally the foot broadens out at its base into a kind of 'clasping-disc.' The three animals of this species which were at my disposal represented stages of different age. In the oldest individual the bladder-like body has been irregularly contracted by preservation in spirit, its exterior is folded, and exhibits besides a lateral compression. The head region, defined by an obvious constriction, is strongly tuberculate, and marked by twelve coarse radial elevations, separated by discontinuous and incomplete furrows. The height of the body amounts to 2·5 cm., its greatest width to 2·4 cm. Sharply marked off from it by a circular furrow is the cylindrical foot, the diameter of which reaches 1·2 cm. Unfortunately this latter has been broken away, so that I can give no accurate information either about the total length, or about the clasping-disc of this animal. The second polyp was of medium

age; its total length amounted to 3·2 cm., of which 2·0 cm. belong to the body, and 1·2 cm. to the foot. The former is on one side crushed inwards about the middle, where it is of the greatest diameter (2 cm.), while on the other it is as strongly swollen out. Above, it diminishes gradually into the head region, which is indistinctly furrowed radially; and below, equally gradually, into the foot. The latter is cylindrical, and has a diameter of 0·5 cm., while the sole-like clasping-disc has at its base a breadth of 0·9 cm. The third and still younger polyp consists mainly of the 'body,' which above is flat and discoidal, without differentiation of a head-region, but is at the periphery pressed into folds; its height is 2·4 cm., its breadth 2·0 cm. Below it passes gradually into the foot, which is rudimentary, round, only a few millimetres high, and ends without a clasping-disc.

"For investigation I made use of the middle specimen, which was completely preserved. A longitudinal section dividing the polyp into two halves yielded the following results. The mesenteries run in the foot as clear narrow ridges on the body-wall, scarcely projecting into the interior; they extend also on to the horizontal pedal disc, and appear in this region as radiating lamellæ, which meet at the centre of the flat base. The filaments first appear on the mesenteries at the point of transition into the broader 'body;' they form a thick investment, which nearly fills the whole cœlenteron and covers the mesenteries completely. The body-wall is fairly thick, and even with the naked eye can be distinguished into two layers; an outer, which appears granular owing to the accretions, and an inner, which is soft, shining, and free from deposits. It is further noticeable, that the quantitative relations between the incrusted and the softer layers vary with the height of the part in question, and in such a manner that, at the upper part of the body, both parts are about equally strongly developed, while with increasing depth the harder constituents become more numerous, till at last, in the foot, a complete obliteration of the softer zone is produced. Above, the body-wall is drawn rather deeply inwards at a sharp angle. On to this infolded region the accretions are uninterruptedly continued as far the point of origin of the oral disc, the latter being inserted just at the inner edge of the fold. The stomatodæum reaches far downwards, and is characterised by a siphonoglyphe of considerable depth.

"A transverse section in the region of the stomatodæum allows the mesenterial arrangement to be recognised even by the naked eye. The longitudinal section having been carried midway between two mesenteries on both sides, they were completely intact, and the combination of the two sectional halves yielded a complete picture of the mesenterial arrangement, which falls under the microtype. Sixty mesenteries in all are present; of these, after deduction of the regularly formed dorsal pairs, there fall into the ventral zone on each side of the directive macromesenteries, twelve pairs, consisting each of a macro- and a micro-mesentery.

"For a study of the anatomical relations in more detail, I made use of von Koch's

method of grinding. The integument is composed, as was stated above, of an internal softer zone, and an external zone penetrated by accessory deposits. The latter consist mainly of clear angular fragments of sand; but there occur also various indeterminable mineral splinters of different colours, and finally, more sparingly, sponge-spicules and Foraminiferal shells. All these particles lie confusedly mingled, and so closely together as to form a stout external rind; between them they allow of only thin mesoglœa-lamellæ, in which are embedded fine nucleated fibres, as well as a few stellate mesoglœal cells. The zone of mesoglœa which is soft and free from deposits, consists of a homogeneous matrix, in which sharply circumscribed lenticular cell-islets are embedded in large numbers and of various sizes. They are especially plentiful in the neighbourhood of the endoderm; but, in passing outwards, every gradation of size, up to fine fusiform structures, is met with. The plane of the long axis of these cell-islets is always circumferential. The nucleated fibres are extremely abundant in the mesoglœa; they extend from the endoderm outwards, their course being sometimes straight, but more generally undulating, with close coils almost like a cork-screw. Besides the contents already mentioned, one observes also the existence of stellate mesoglœal cells, which are sparsely scattered and emit fine processes into the homogeneous matrix.

"The supporting lamina of the mesentery is well developed, and presents an antler-like muscle-pennon. At its base passes a canal, filled with cells, and penetrating the mesenteries for their whole length; in transverse sections through the micromesenteries this appears simple and cylindrical, but forms on the macromesenteries a longer cavity divided up by cross anastomoses. This quite subordinate character accompanies the microtype through all the genera, however different both externally and anatomically; no macrotypal form showing even a trace of this mesenterial canal.

"The sphincter of *Sphenopus* is mesodermal and simple, and is so far characteristic that it commences incomparably deeper than in any other known Zoanthean; it extends so deeply downwards in the outer part of the body-wall, that, even in the contracted animal, its lowest point lies in the same horizontal plane as the lower end of the stomatodæum. In longitudinal section one can see how, at its deepest point, the bundles of fibrillæ, like small circles, are laid so closely together that they appear almost to form a continuous line. Above they are more extended, and place themselves with the long axis perpendicular to the endoderm, from which they are only separated by a narrow lamina of homogeneous mesoglœa. In this condition the sphincter forms a system of bacillate fibrillæ-bundles, which are arranged extremely regularly in the form of a palisade. At the edge of the infolding of the body-wall the bundles begin to bay out irregularly, and finally set themselves, on the indrawn part of the body-wall, to form the sphincter proper, a plait of delicately branching and anastomosing bundles. This circular muscle increases in bulk downwards, and terminates below with a rounded

end. It does not completely traverse the mesoglœa, but leaves free on either side a homogeneous layer, which in its turn is bounded by a stripe reaching to the commencement of the oral disc, and carrying the usual hard deposits."

Sphenopus arenaceus, R. Hertwig.

Habitat.—Station 187, Torres Strait, Australia, September 9, 1874; 6 fathoms. Two specimens.

Sphenopus marsupialis, Steenstrup.

Habitat.—(*a*) Station 188, in the Arafura Sea, September 10, 1874; 28 fathoms. One specimen. (*b*) Station 208, Philippine Islands, January 17, 1875; 18 fathoms. One specimen.

In the Challenger material I have found four further examples of the genus *Sphenopus;* two of these I have determined as *Sphenopus arenaceus* on account of their rusty red tint, and other two as *Sphenopus marsupialis*, in consequence of the earthy-grey colour and the absence of a stalk. It seems to me, however, desirable that, with an opportunity of more abundant and fresh material, a renewed study should be undertaken to decide whether the received specific characters are variable, and whether all three species should not be united in the single *Sphenopus marsupialis*.

APPENDIX TO THE ZOANTHEÆ.

Genus *Stephanidium*, n. gen.

Among the Zoantheæ I include with some reserve a genus which is represented by a single species, and has thus been insufficiently investigated. It differs from the characteristic forms of Zoantheæ in the absence of incrustations, and the non-formation of a colony. Both characteristics, however, may be absent in true Zoantheæ, *e.g.* the soft-skinned *Zoanthus* and the solitary Sphenopidæ. Of more importance is the fact that, in spite of careful study, I have not yet been so fortunate as to demonstrate beyond all doubt the decisive characteristic of Zoantheæ, namely, the regular distribution of micro- and macro-mesenteries. I consequently omit to give separate diagnoses of the species and genus.

Stephanidium schulzii, n. sp. (Pl. I. fig. 14; Pl. III. figs. 1, 7).

Habitat.—Station 209, off Zebu, Philippine Islands, January 22, 1875; 95 fathoms.

Dimensions.—Breadth, 1·5–2·2 mm.; height, about 1·0 mm.

Some Actiniæ were forwarded to me by Prof. F. E. Schulze, found among the Hexactinellidæ entrusted to him for description; they were mainly small, insufficiently characterised forms, which I did not care to investigate; but among them occurred five

specimens of one species, which I will here describe on account of the striking appearance of the body.

The body of Stephanidium is in diameter 1·5–2·2 mm., and about 1 mm. high in the contracted condition. The epithelium had been stripped off at most points, and remained only on the lowest parts of the body-wall, the mesoglœa thus being exposed over a wide extent, and allowing the mesenteries to be seen through it. The resulting appearance is drawn in Pl. I. fig. 14, and was originally interpreted as follows:—I believed that the surface was indented by deep furrows corresponding to the mesenteries; the ridges lying between these furrows become narrower, from a definite part of the body-wall outwards; they are extremely unequal in breadth, a broader and a narrower ridge alternating regularly with one another, and to every broader ridge corresponds, at the upper edge of the body-wall, a special structure of the following nature: the edge of the body-wall is elevated into a kind of battlement (Pl. III. fig. 7), on the outer side of which are situated roundish or oval bodies, which call to mind the marginal spherules of *Actinia mesembryanthemum*. The longitudinal ridge of the body-wall meets the spherule, splits into two forks, and surrounds the structure from below.

Sections through the animal, however, showed that the body-wall is smooth, and that the appearance of furrows was caused by the insertions of the mesenteries. On the other hand, the spherules are really present, and form evaginations of the body-wall, above a spot which is marked by the position of the circular muscle (Pl. III. fig. 1). The latter, in spite of the contracted condition of the Actinian, is of weak development, and is merely a part of that endodermal circular muscle-layer which is at other points hardly recognisable, but is here elevated into small folds. It is most obvious at those places where it traverses the thickness of a mesenterial insertion; here the endodermal muscle-layer is not recognisable, but mesoglœal muscle-rings are embedded in the region of the sphincter, largest at the upper end, and becoming gradually less obvious in a downward direction, till one meets with small groups of only two or three fibres, or even with completely isolated fibres.

Of the tentacles and oral disc it can only be said that the ectodermal muscle-layer is strongly pleated.

The mesenteries, the number of which may be learnt even by superficial observation, amount to twenty-six, and are differentiated, as in the Zoantheæ, into macro- and micro-mesenteries. Of their arrangement, despite much trouble, I have not yet arrived at a completely clear comprehension, but I could demonstrate the probability that the directives of the one side are macro-mesenteries, those of the other micro-mesenteries, that dorsal and ventral mesenterial zones meet with micro-mesenteries, and that one pair is more developed on the one side than on the other.

The mesenteries (probably only macro-mesenteries) bore ripe male generative organs. I was unable to recognise a siphonoglyphe.

24

V. CerianTheæ.

Family 15, Cerianthidæ.

Genus *Cerianthus*, Delle Chiaje.

Cerianthus membranaceus, Spall.

Habitat.—Zebu, Philippine Islands, on the reefs.

Dimensions.—Length, in a contracted condition, 4·5–10·0 cm.; breadth, 1·5–1·8 cm. Two specimens.

UNDETERMINED SPECIMENS.

1. Station 153, in the Antarctic Ocean, February 14, 1876; 1675 fathoms.
   An Actinian, nearly as thin as paper, strongly contracted and folded together, 1·5 cm. in size.
2. Station 173, off Matuku, Fiji Islands, July 24, 1874; 310–315 fathoms.
   An Actinian, firmly fixed on a Gastropod shell (probably an *Adamsia*).
3. Station 195, off Banda, October 3, 1874; 1425 fathoms.
   An Actinian, about 5 cm. long, very rotten.
4. Station 209, off Zebu, Philippine Islands.
   An Actinian, 4 mm. broad, 2 mm. high, sessile, strongly contracted.
5. Zebu, 100 fathoms.
   An Actinian, 6·0 mm. broad, 2 mm. high, of the usual structure; 12 complete pairs of mesenteries, two directives, 36 (= 12 + 24) small pairs.
6. Station 219, North of Papua, March 10, 1875; 150 fathoms.
   One small Actinian, 1·5 cm. high, 1·5 cm. broad, slightly contracted (probably no sphincter), about 30 short, plump, sack-like tentacles. Preservation inadequate for study.
7. Station 244, North Pacific, East of Japan, June 28, 1875; 2900 fathoms.
   One Actinian, 12 mm. broad, 3 mm. high, very strongly contracted.
8. Station 286, South Pacific, between Tahiti and Valparaiso, October 16, 1875; 2335 fathoms.
   An Actinian, 1·4 cm. broad, 0·4 cm. high, probably a *Phellia*.
9. Station 299, off Valparaiso; 2160 fathoms.
   Actinian adhering to a *Dentalium;* one elongated specimen (3·5 cm.), flattened by contraction, in shape recalling the Amphianthidæ.

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PLATE I.

PLATE I.

The lettering is the same in all the figures.

cu Cuticula.
ec Ectoderm.
en Endoderm.
g Generative organs.
h Mesenteries.
im Intermediary layer.
m Muscle-fibres.
me Mesoglœa.
ms[1] Upper circular muscle.
ms[2] Lower circular muscle.
o Ova.
r Marginal spherules.
sr Siphonoglyphe (œsophageal groove).
t Tentacles.

All statements given as to magnifying powers have reference to Zeiss's system.

Fig. 1. *Zoanthus danæ.*

Fig. 2. *Epizoanthus elongatus.*

Fig. 3. *Epizoanthus thalamophilus.*

Fig. 4. *Epizoanthus stellaris.*

Fig. 5. *Corticifera tuberculosa.*

Fig. 6. *Corticifera lutea.*

Fig. 7. *Palythoa anguicoma.*

Fig. 8. *Amphianthus ornatum;* × 4.

Fig. 9. *Aulorchis paradoxa;* genital tube exposed by splitting the lip and the stomatodæum.

Fig. 10. *Aulorchis paradoxa;* siphonoglyphe, stomatodæum, oral disc, and mesenteries exposed on removal of about one-third of the animal.

Fig. 11. *Sphenopus pedunculatus.*

Fig. 12. *Zoanthus confertus.*

Fig. 13. *Liponema multiporum;* oral disc and stomatodæum evaginated.

Fig. 14. *Stephanidium schulzii;* × 30.

Fig. 15. *Epizoanthus cancrisocius.*

(Figs. 1–7, 11, 12, 15 are after Erdmann.)

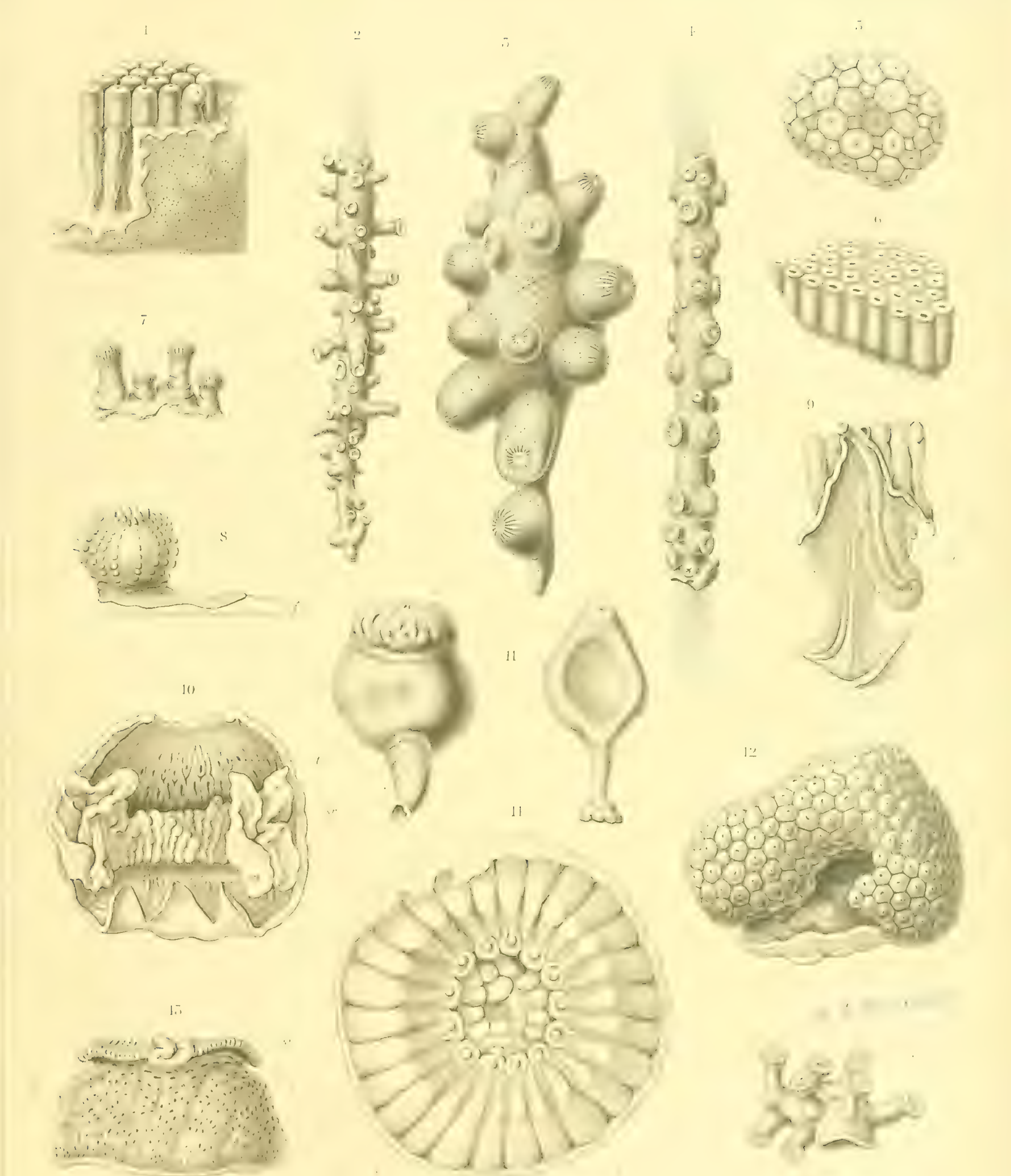

PLATE II.

PLATE II.

The lettering is the same in all the figures.

cu Cuticula.
ec Ectoderm.
en Endoderm.
g Generative organs.
h Mesenteries.
im Intermediary layer.
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ms[1] Upper circular muscle.
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r Marginal spherules.
sr Siphonoglyphe (œsophageal groove).
t Tentacles.

All statements given as to magnifying powers have reference to Zeiss's system.

Fig. 1. Portion of the circular muscle of *Hormathia delicatula.* D, Oc. 2, somewhat diminished.

Fig. 2. *Ilyanthopsis longifilis;* musculature of the oral disc. $^{1}/_{18}$, Oc. 1.

Fig. 3. *Hormathia delicatula;* musculature of the oral disc. D, Oc. 2.

Fig. 4. Circular muscle and marginal spherules of *Liponema multiporum.* A, Oc. 1.

Fig. 5. Muscle-pennon of *Halcampa kerguelensis.* A, Oc. 2.

Fig. 6. *Dysactis crassicornis;* transverse section through a tentacle. a^3, Oc. 2.

Fig. 7. Portion of the tentacle represented in fig. 6, more strongly magnified. A, Oc. 1.

Fig. 8. *Phellia spinifera;* transverse section through the musculature of the oral disc. E, Oc. 2.

Fig. 9. The same.

R. Hertwig del.

PLATE III.

PLATE III.

The lettering is the same in all the figures.

cu Cuticula.	*me* Mesoglœa.
ec Ectoderm.	ms^1 Upper circular muscle.
en Entoderm.	ms^2 Lower circular muscle.
g Generative organs.	*o* Ova.
h Mesenteries.	*r* Marginal spherules.
im Intermediary layer.	*sr* Siphonoglyphe (œsophageal groove).
m Muscle-fibres.	*t* Tentacles.

All statements given as to magnifying powers have reference to Zeiss's system.

Fig. 1. Circular muscle of *Stephanidium schulzii*;—1*a*, in the region of an intermesenterial chamber and of a marginal spherule; 1*b*, in the region of the origin of a mesentery.

Aulorchis paradoxa (figs. 2–6).

Fig. 2. Transverse section through the oral disc. A, Oc. 1, somewhat diminished.

Fig. 3. Parts of a transverse section through the circular muscle, showing the connection of the endodermal and mesoglœal muscle-layers: 3*a*, with D, Oc. 1; 3*b*, with E, Oc. 1.

Figs. 4, 5. Sections through the stomidia. a^3, Oc. 1.

Fig. 6. Transverse section through the mesoglœal musculature of the oral disc. D, Oc. 1.

Fig. 7. *Stephanidium schulzii*; upper edge of the body-wall, × 60.

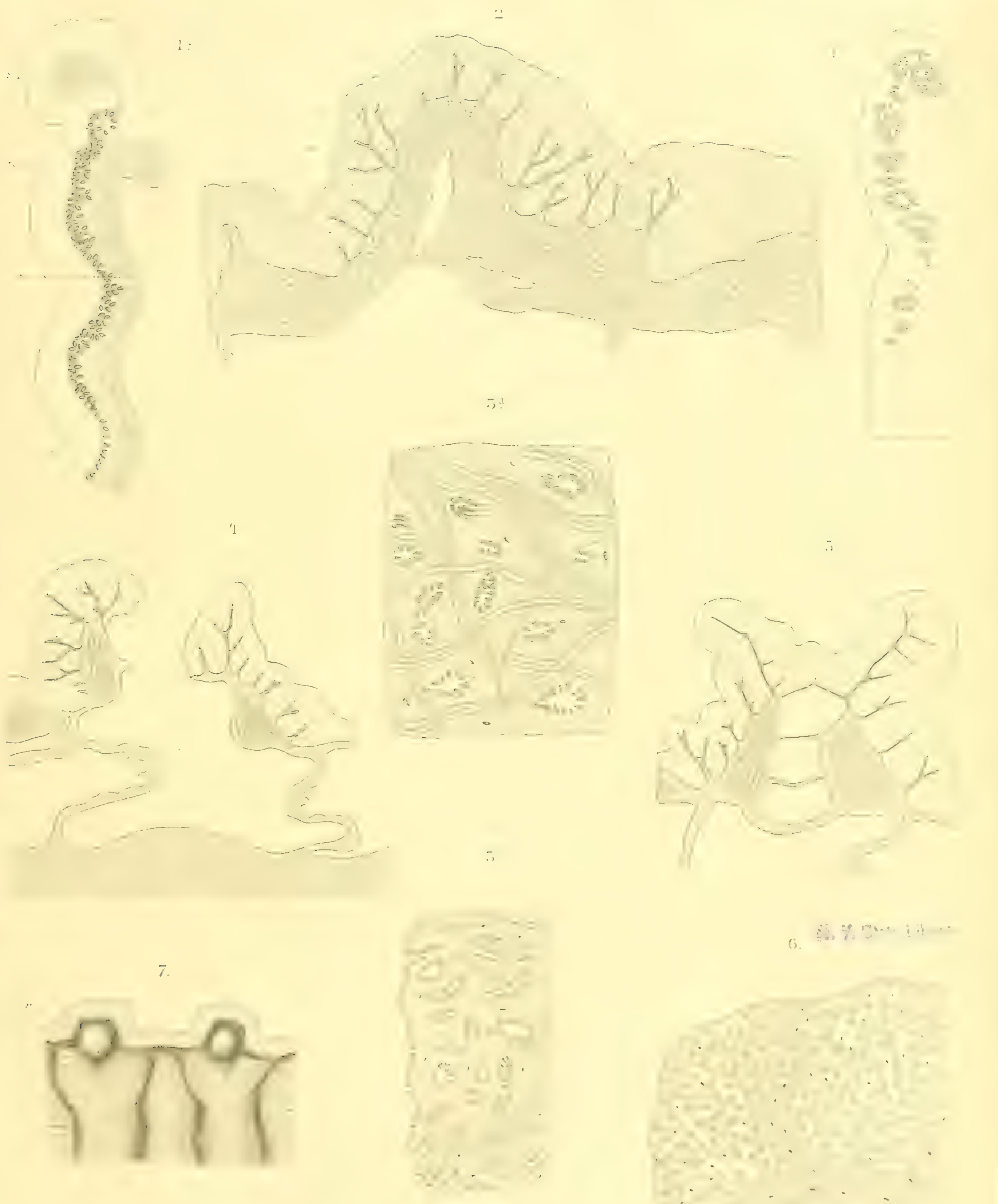

1
2
4
5
7.
6.

PLATE IV.

PLATE IV.

The lettering is the same in all the figures.

cu Cuticula.	*me* Mesoglœa.
ec Ectoderm.	*ms*[1] Upper circular muscle.
en Entoderm.	*ms*[2] Lower circular muscle.
g Generative organs.	*o* Ova.
h Mesenteries.	*r* Marginal spherules.
im Intermediary layer.	*sr* Siphonoglyphe (œsophageal groove)
m Muscle-fibres.	*t* Tentacles.

All statements given as to magnifying powers have reference to Zeiss's system.

Aulorchis paradoxa (sections through the genital tube, figs. 1–6).

Fig. 1. Connection of an ovum with the endodermal epithelium, probably by means of a thread apparatus ("Faden-Apparat"). E, Oc. 2.

Fig. 2. Surface view of the germinal layer. I, Oc. 2.

Fig. 3. Longitudinal section through the germinal layer. E, Oc. 2.

Fig. 4. Transverse section through the lower part of the genital tube. A, Oc. 2.

Fig. 5. Transverse section through the upper part of the genital tube, in the region of the oral disc; the central detritus, which is probably produced by degradation of epithelium, is omitted in the drawing. A, Oc. 2.

Fig. 6. Epithelial layer from the interior of the genital tube (cf. fig. 4). E, Oc. 1.

Fig. 7. *Epizoanthus thalamophilus;* section through the circular muscle (after Erdmann).

Fig. 8. Horizontal section through the external and the invaginated portions of the body-wall of *Epizoanthus thalamophilus* (after Erdmann).

Fig. 9. *Hormathia delicatula.* Portion of the partly invaginated body-wall cut out and magnified slightly. The invaginated part bears the parietal spherules.

Hertwig et Erdmann del.

THE

VOYAGE OF H.M.S. CHALLENGER.

ZOOLOGY.

REPORT on the PENNATULIDA dredged by H.M.S. Challenger during the years 1873–1876. By Professor Rudolph ALBERT V. KÖLLIKER, F.M.R.S., &c., &c.

IN accordance with the request of Sir Wyville Thomson, I undertook the description of the PENNATULIDA collected by the Challenger Expedition. With the exception of *Umbellula thomsoni*, the whole collection came into my hands in April 1879. I devoted the whole of the succeeding summer to the investigation, and sent my MSS., with a number of plates drawn by Mr Rabus of Würzburg, to Sir Wyville Thomson in the beginning of August of the same year.

Want of time, and the nature of the material forwarded to me, prevented me from going deeply into anatomical details, and there was, perhaps, the less reason for my doing so, as my monograph of the Pennatulida (Anatomisch-systematische Beschreibung der Alcyonarien, Frankfurt, 1872) gives to those who have a special interest in this department an opportunity of gaining a clear insight into the structure of the group.

The following is a description of all the Challenger PENNATULIDA according to the classification given at the end of this paper :—

Order PENNATULIDA.

Section I. PENNATULEÆ.

Sub-section I. PENNIFORMES.

Family 1. PTEROEIDIDÆ.

Pteroeides, Herklots.

1. *Pteroeides esperi*, Herkl.

This species is represented by five entire specimens of different ages, and a larger number of fragments. All were collected at Station 212, lat. 6° 55′ N., long. 122° 15′ E., off Mindanao, one of the Philippine Islands, on the 28th January 1875, at depths of 10, 14, and 20 fathoms.

The larger and more fully developed specimens correspond pretty closely with my *Pteroeides esperi*, var. *latifolia*, which was collected by Professor Semper at nearly the same locality (near Bohol); but the Challenger specimens, like those of Professor Semper, vary in the form of the leaves, which are also larger in some specimens and smaller in others, in colouring, and in the number of the leaves and the number of their spines.

The largest perfect specimen measures 132 mm. in length, of which 99 belong to the pinnuliferous part, and 54 mm. in breadth. The broadest imperfect specimen is 80 mm. broad, and the pinnuliferous portion 84 mm. long. The number of leaves in both specimens is twenty-five, and that of their spines eight in the first and ten to twelve in the second.

2. *Pteroides breviradiatum*, Köll.

Two well-preserved specimens, with the label, "6th May 1875, Yokohama, Japan, 5–25 fathoms."

The larger of these specimens measures 180 mm. in length and 100 mm. in breadth, the other is 145 mm. long and 85 mm. broad. They are identical in structure, and agree pretty well with my variety *latifolia*. The whole polypidom is colourless, with the exception of the polypiferous border of the pinnæ, which is pale blue.

Sarcophyllum, Köll.

Sarcophyllum grande, Gray.

Three fragments with the label, "Port Jackson, 6–15 fathoms."

All three are colourless, and rich in small calcareous needles in the polypiferous zone of the pinnules.

Family 2. Pennatulidæ.

Pennatula, L.

1. *Pennatula naresi*, n. sp. (Pl. I. figs. 1, 2).

Polypidom large, red and yellow in colour; pinnules triangular, hard, not transparent; polyp-cells alternating, numerous, with eight long spines; polyps with small calcareous spicules in the tentacles and in the stomach walls; zooids lateral and ventral, the latter in sets beginning at the ventral borders of the pinnules.

Feather more than double the length of the stalk, and more than four times longer than broad.

Pinnules twenty-nine, of which the lowest six or eight are rudimentary; the exact form of these could not be determined, as this portion of the single specimen is defective. The fully-developed pinnules are triangular, with a curved free end. The expanded base is

placed very obliquely on the rachis, so that its dorsal portion, which reaches the middle line of the rachis, runs in a longitudinal direction. The ventral margin of the pinnule is concave, thickened, and beset with irregular wart-like protuberances; whilst the dorsal convex border bears the closely set polyp-cells, thirty to thirty-four in number, which alternate in such a manner as to give the appearance of two rows. Besides the more fully-developed cells, each pinnule has at the dorsal end of its polypiferous margin from three to five smaller or rudimentary cells, which are not to be confounded with the zooids. The polyp-cells are in part well separated, and together with the eight strong spines at their opening, 3 to 4 mm. long; in part shorter, more or less confluent; and some are as if imbedded in the pinnules, and only free at their openings.

The rachis is nowhere free on the dorsal side of the feather, but on the ventral aspect its middle line is not covered by the zooids. These are ventral and lateral. The ventral zooids form thick prominent yellow spiny bands, which begin at the ventral margin of the pinnule at a little distance from its attachment, run obliquely upon the sides of the rachis, and end with a longitudinal streak, the point of which reaches the next band of zooids, so that all the ventral zooids together form one continuous line on each side, giving offsets to each leaf. The zooids themselves are crowded on each band, larger and smaller, and largest in the neighbourhood of the pinnule. The lateral zooids fill the intervals between the leaves, are numerous toward the ventral side of the rachis, where they reach the ventral zooids, and run out with a single row at the outside of the dorsal attachment of the pinnule; they are all much smaller than the ventral zooids, but they are also armed with projecting spines.

The stalk is thickened at the upper end, and seems to terminate inferiorly in a rounded point. The colour of the whole polypidom is generally red, and darker on the stalk, with the exception of its lower end which is pale red, becoming colourless towards the tip. The feather is pale red, with the exception of the polyp-cells and ventral zooids, which are yellow. The axes of the polyps and their stomach-walls are also red. All coloured parts owe their colour to calcareous needles of characteristic form. Uncoloured calcareous bodies are found at the lower end of the stalk.

Maximum length of the yellow needles of the polyp cells,	1 mm.
Breadth,	0·058
Maximum length of the red spicules of the pinnules,	0·85 to 0·90
Width,	0·021 ,, 0·027
Uncoloured bodies of the end of the stalk, round or elliptical,	0·004 ,, 0·015
Length of the whole polypidom,	300
Length of the stalk,	84
Breadth of the feather,	43
Breadth of the stalk,	8
Breadth of the enlargement of the stalk,	10·5
Breadth of the base of the pinnules,	17–19

Habitat.—A single specimen from Station 232, south of Yeddo, Japan, lat. 35° 11′ N., long. 139° 28′ E. Depth, 345 fathoms. Sandy mud. Bottom temperature, 5° C. May 12, 1875.

Pennatula naresi at first sight somewhat resembles *P. grandis*, Ehrenberg (*P. borealis*, Sars, *Ptilella grandis*, Koren and Danielssen), but on closer inspection the differences are numerous and great. Before entering into this subject, I wish to say that I cannot accept the genus *Ptilella* of Gray, which has been defined by him as follows:—"Pinnules membranous, broad, rounded, fringed with three close parallel series of short polyp-cells on the edge. Rachis granular on each side behind without any spines." Koren and Danielssen have accepted the genus *Ptilella*, and define it as follows:—"Very large sea-pens, with large, broad, semilunar fins bearing several rows of polyp-cells. The ventral surface naked. The zooids lateral, extending towards the centre of the dorsal surface. On the ventral margin of the fins strongly developed zooids. The sexual organs in the fins. On the upper part of the stalk a fleshy enlargement. The axis is thick and round, curved downwards in the form of an S, terminating in a hook, while in the upper part it terminates in a volute." With regard to this definition I have to add, (1) that *Pennatula grandis*, Ehrb., has very fully developed ventral zooids, which are tolerably well represented in fig. 2 of Sars; and (2) that this species has also a row of zooids at the dorsal end of the polypiferous margin of the leaves on the ridge, with which each leaf runs out upon the rachis. Now, if we define, as I have done, the Pennatulidæ as sea-pens with well-developed leaves, which bear the zooids principally upon the ventral surface of the rachis; and the genus *Pennatula* as a pennatulid the leaves of which are beset in their totality with calcareous needles, whilst these are found only in the polypiferous zone, in the genera *Ptilosarcus* and *Leioptilum*, and are totally wanting in *Halisceptrum*,—*Pennatula grandis* is a true *Pennatula*. At all events, I would rather unite the genera *Ptilosarcus* and *Leioptilum* with *Pennatula* than subdivide the *Pennatulæ* on ground so slight as the number of rows of polyp-cells, the size of the enlargement of the stalk, the disposition of the zooids in each group, or even the presence or absence of zooids on the ventral and dorsal margins of the leaves.

2. *Pennatula pearceyi*,[1] n. sp. (Pl. II. fig. 5).

Small, of a reddish colour, with four to five polyps on the margin of the small lanceolate pinnules. Zooids ventral and lateral, two to four in each set, small, all of the same size. Feather more than double the length of the stem.

Pinnules thin, transparent, slender, obliquely attached to the rachis, 3 mm. broad at their base. Ventral margin of the pinnule straight, dorsal margin with obliquely disposed polyp-cells, and thus appearing serrated. Free end of the pinnule formed by one polyp-cell.

Polyps four to five on the dorsal margin of the pinnule, and two to three small

[1] Named after Mr Frederick Pearcey, an excellent assistant attached to the Civilian Staff.

zooid-like individuals on that part of the margin which runs out upon the rachis. Polyp-cells of the larger polyps united inferiorly, free at their ends, which are surrounded by short spines.

Ventral zooids, three in number, longitudinally disposed at the base of each pinnule. Lateral zooids, three to four, at the dorsal side of the ventral zooids along the base of the pinnules. All the zooids are small, white, and surrounded by red spicules.

Rachis small, thicker than the stem. Colour of pinnules and rachis pale red, polyps white. Stem white, with a small enlargement at each end. Calcareous needles of the common type; the red needles of the feather measure 0·53 mm. by 0·028 mm. Colourless needles of 0·15 to 0·20 mm. in length, and 0·020 to 0·026 mm. in breadth, are situated in the cutaneous layer of the upper part of the stalk, and the end bulb contains minute oblong and round calcareous corpuscles of 3 to 12 μ. The Challenger collection contains two specimens of this Pennatulid, one pretty well preserved and a second in a fragmentary state.

	A.	B.
Length of the feather, ...	44 mm.	51
Length of the stalk, ...	21	20·5
Length of the pinnules, ...	11	
Breadth, ...	2·5–3·0	
Breadth of the rachis, ...	1·5	

Habitat.—Station 235, south of Japan, lat. 34° 7′ N., long. 138° 0′ E. Depth, 565 fathoms. Bottom temperature, 3°·3 C. June 4, 1875.

3. *Pennatula murrayi*, n. sp. (Pl. II. figs. 6, 7).

Small, yellow and red in colour. Pen twice and a half as long as the stalk. Pinnules lanceolate, triangular, transparent, with nine to ten polyps on their margin; calyces with well developed spines. Zooids ventral and lateral, the ventral of two kinds, two large at the base of each pinnule and many smaller, forming one longitudinal row on each side.

Pinnules lanceolate, thin, transparent, yellow, with a vermilion-coloured ventral border; twenty-one to twenty-two in number, attached nearly parallel to the longitudinal axis of the rachis, but so that the dorsal upper end of their base reaches the dorsal middle line.

Polyps nine to ten on the more developed pinnules, placed in one single row on the dorsal margin; calyces the colour of minium, with eight well-developed spines.

Rachis yellow, with ventral and lateral zooids. The ventral zooids are of two kinds. Larger spiny and reddish zooids, two in number, are situated at the base of each pinnule just opposite the middle part; smaller and whitish rudimentary polyps are disposed in one single row on each side between the larger ones. Zooids of the same kind are also placed laterally between the pinnules in a single or partly double row, so that they are only visible from the ventral side of the feather. The lower part of the rachis of the only

specimen of this *Pennatula* was evidently beset with small pinnules, of which remnants were still visible ; the exact number of these could not, however, be determined, therefore the number of twenty-one to twenty-two is only approximate.

The stem has an enlargement at the upper end, the upper part of which is of the same sulphur-colour as the rachis, while the lower portion is colourless like the rest of the stem. This lower part diminishes in size till near the end, where there is a small swelling or bulb covered with minute papillæ only visible under the microscope.

The whole feather, with the exception only of the polyps, is furnished with a large number of yellow and red calcareous needles of the form common in the Pennatulidæ. Yellow needles are also found in the stem where it is coloured yellow. The lower part of the stalk is destitute of calcareous bodies with the exception of the end-bulb, which contains very small round and oblong calcareous corpuscles.

The only polypidom at my disposal was of female sex, and the eggs were situated in the pinnules.

Length of the whole polypidom,	140 mm.
Length of the whole stalk,	40
Length of the whole feather,	100
Length of the longest pinnules,	17
Breadth of the pinnules at the base,	53
Breadth of the upper enlargement of the stem,	3·30
Maximum length of the yellow needles,	1·28
Maximum breadth,	0·085
Maximum length of the red needles,	0·85
Breadth of the red needles,	0·041
Calcareous bodies of lower bulb of stalk,	0·007–0·011

Habitat.—Station 192, on the south-east of Ceram, west of New Guinea, lat. 5° 42′ S., long. 132° 25′ E. Depth, 129 fathoms. Mud. September 26, 1874.

4. *Pennatula moseleyi*, n. sp. (Pl. II. figs. 8, 9).

The Challenger collection contained only one specimen of this remarkable species, consisting of a fragment of the pen 138 mm. in length ; but this fragment showed characters sufficiently marked to cause it to be recognised as a good species. Polypidom large, intensely red. Pinnules thick, not transparent, crowded, triangular and lanceolate, curved at their free end, and with thirty to thirty-four polyps in two or three rows on their border. Polyp-cells with spines. Zooids of two kinds, the ventral beginning at the border of the leaves, large and spiny, the lateral small.

Pinnules twenty-six in number on each side of the fragment, of which the upper end is wanting. Form of the pinnules nearly triangular or lanceolate. Their broad basis obliquely attached to the rachis, the polypiferous dorsal border convex and much longer than the concave ventral margin, so that the free end of each pinnule is curved like a hook.

Polyps arrayed in two or three rows on the dorsal margin of the pinnules, with well-separated cells or calyces 3 mm. in length, the apertures of which are surrounded by eight strong spines. Total number of polyps on a leaf 30 to 34.

Rachis of a medium thickness, with two kinds of rudimentary polyps or zooids. One set, the ventral zooids, consists of a row of larger spiny zooids, which begins at the ventral margin of the pinnules, at 3 to 4 mm. from their attachment, runs obliquely towards the ventral side of the rachis, and there changes its direction so as to become longitudinal. Each row has the aspect of a curved spiny ridge, and shows the openings of the zooids as whitish points arranged in one single series.

The lateral zooids begin with a large crowded mass at the dorsal side of the ventral zooids, but as soon as they reach the interspace of the pinnules their number greatly diminishes, and they end with a double or single row near the dorsal attachment of the pinnules. These zooids have only small spines or none at all, and look more like small rounded or conical papillæ.

The rachis has between the zooids on its ventral side a free space of 2·5 to 4·0 mm. in breadth, and looks here as if it were beset with little papillæ or wart-like bodies. In one part of the pen some two or three zooids seem to occupy a portion of the groove. The dorsal side of the rachis is destitute of a free middle line, as the leaves somewhat overlap each other.

The colour of the whole fragment, which is deep red, is occasioned by red spicules lying in the integument. The greatest number of these is found in the polyp-cells, and on both margins of the leaves, while the surfaces of the latter are pale red and whitish. A whitish colour is also found on the ventral side of the rachis, but this is only produced by the thick epithelium of this part, which contains many thread-cells, while the subjacent cutis is red. The polyps themselves are not coloured, and the same holds good of the whole interior of the pinnules and the rachis. The spicules are of the typical form of those of the Pennatulidæ, with a maximum length of 1·14 to 1·2 mm., and a maximum breadth of 0·058 mm. The minute and microscopic structure of this *Pennatula* corresponds, as far as I can judge, with that of the *Pennatula rubra* described in my monograph; but I have to remark that in the Challenger example the calcareous axis is wanting, having evidently been torn out of the fragment by accident.

The fragment belongs to a female polypidom, and the eggs are found in the pinnules.

Length of the pinnules measured in the curved state,	12–14 mm.
Breadth at base,	10–12
Breadth at their free end without the polyp-cells,	3–4
Breadth of the rachis,	5–6

Habitat.—Station 164, off Sydney, Australia, lat. 34° 8′ S., long. 152° 0′ E. Depth, 950 fathoms. Temperature, 2°·2 C. Grey ooze. 12th June 1874.

5. *Pennatula sulcata*, n. sp. (Pl. II. figs. 3, 4).

General character of *Pennatula rubra* and *Pennatula fimbriata;* colourless, with a deep groove on the dorsal side of the rachis; the leaves are very numerous; ventral and lateral zooids are present, the latter of which are also visible on the dorsal aspect of the rachis. Besides these there is a long row of zooids at the dorsal end of the polypiferous margin of the leaves.

Feather more than twice the length of the stalk.

Pinnules thin, transparent, closely set, twenty-six to twenty-seven in number, lanceolate or triangular. Base of the pinnule attached transversly to the rachis. Ventral and dorsal margin straight, the latter beset with one row of polyp-cells, alternating so as to produce the appearance of two rows, especially near the dorsal end of the border. The polypiferous margin of each pinnule ends in a long narrow ridge, which runs obliquely upon the dorsal side of the rachis, as far as the base of the next pinnule. This ridge is merely a single row of small zooids about twenty-seven in number, and of the size of 0·10 to 0·12 mm., which I call the zooids of the dorsal margin of the pinnules.

Polyp-cells small, crowded, twenty-four to twenty-six on the larger pinnules; and pretty well separated, with eight strong spines.

Rachis with a groove on its dorsal side, which begins shallow between the lowest pinnules, assumes a depth of 3 mm. toward the middle of the feather, and runs out at its upper end. This groove is narrow where it is deepest, and bordered by sharp whitish lips. The calcareous axis lies inside at the bottom of the groove, and shines through the thin integument as a white streak. The ventral side of the rachis is covered on its sides by small zooids, while the middle line is smooth. These ventral zooids are small wartlike or conical bodies, 0·2 mm. in breadth, all of one kind with this exception only, that those near the pinnules have their calcareous needles projecting, and resemble small spines, whilst the others are rather rounded protuberances. These zooids are continuous between the pinnules with very numerous lateral zooids of rounded form, which run up to the dorsal aspect of the rachis, and reach as far as the ridges of the pinnules described above, on the side of which they end with a pointed train. The stalk is short, enlarged in its upper part, and pointed at the end.

With regard to the internal structure I have only to make the following remarks:—The eggs are found in the leaves, and, as it appears, also in the stalk, as in *Pennatula rubra*, if we may judge from the fact that the stalk contains on both sides a crowded mass of eggs along the attachment of the pinnules. Calcareous corpuscles are found in the whole integument. In the polyps short stout needles of 0·11 to 0·20 mm. lie in the stem of the tentacles. The polyp-cells contain needles of 0·86 mm. maximum length, and 0·032 mm. breadth. Those of the lateral and ventral zooids are numerous but smaller, and those of the zooids of the pinnules are smallest, measuring only 0·081 to 0·10 mm. in length. Besides these needles the rachis contains none except at the ventral side, where needles of 0·050 to 0·080 mm. are found in the lips which border the longitudinal groove.

The stalk is very rich in flat elliptical calcareous corpuscles resembling those of *Veretillum*, the maximum size of which is 0·1 mm., while the greater majority are not more than 27 to 54 μ long, and many measure only 5 to 10 μ.

Length of the stalk,	29 mm.
Length of the feather,	58
Length of the longest pinnule,	20
Breadth of the longest pinnule at base,	4·5
Breadth of the longest pinnule at rachis,	10·0
Breadth of the longest pinnule at stalk,	5·0

Habitat.—Station 203, Zebu, Philippines, lat. 11° 7′ N., long. 123° 7′ E. Depth, 10 to 20 fathoms. Mud. October 31, 1874. One single specimen.

Halisceptrum, Herklots.

Halisceptrum gustavianum, Herkl., var. *parvifolia*, mihi.

Of this form the Challenger collection contains four fragments, from Station 212, off Mindanao, one of the Philippines. Lat. 6° 55′ N., long. 122° 15′ E. Depth, 10, 14, and 20 fathoms. Sand. January 30, 1875.

Sub-section II. VIRGULARIEÆ.

Family 1. Virgularidæ.

Virgularia, Lam.

1. *Virgularia bromleyi*, n. sp. (Pl. III. fig. 10).

Of this species the Challenger got only one small fragment.

Polyps nearly sessile, so that there is only a very faint appearance of pinnules, and they must at all events be called very small. Pinnules nearly opposite, each group about 4 mm. distant from its neighbours. Polyps with their cells 2·5 to 2·8 mm. long, three in each pinnule, with pretty well-marked cells, the margin of which has no spines nor protuberances of any kind.

Rachis small, of 0·37 to 0·42 mm., with lateral zooids disposed at the base of the leaves in one single row of three individuals.

Axis round, 0·38 mm. in breadth, with well-developed radial fibres.

Calcareous corpuscles of the ordinary form of needles, 0·085 mm. maximum length, are scantily found in the stalk, the rachis, and the tentacles of the polyps.

Habitat.—Station 235, South of Japan, lat. 34° 7′ W., long. 138° 0′ E. Depth, 565 fathoms. Bottom temperature, 3°·3 C. Mud. June 4, 1875.

2. *Virgularia gracillima*, n. sp. (Pl. III. fig. 11).

A fragment of a *Virgularia* may be so named provisionally, as it seems to differ from all known species.

Pinnules very small, about 0·85 mm. high, and 1·1 mm. distant from each other.

Polyps four on each pinnule, without well-marked cells.

Rachis small, with a breadth of 0·48 to 0·51 mm. in the middle part, and of 0·62 in the region of the undeveloped pinnules.

Zooids.—(?)

Axis round, yellow, 0·42 mm., large in the lowest part of the rachis, with the typical well-developed radiating fibres. Length of the whole fragment 77·5 mm.

Habitat.—Station 167*a*, Queen Charlotte Sound, near Long Island, New Zealand. Depth, 10 fathoms. Mud. June 27, 1874.

Scytalium, Herkl.

1. *Scytalium sarsi*, Herkl. (Pl. IV. figs. 14, 15).

Of this remarkable species, the habitat of which has been hitherto unknown, the Challenger got five more or less well-preserved specimens; these agree specifically with the only two specimens known, which are preserved in the Leyden Museum. The only remark I have to make is, that the colour of the polypidom, which depends upon calcareous corpuscles of an opaque red colour, varies very much. One specimen had the whole rachis uncoloured, and only the polyp-cells and stalk red. In a second the rachis was uncoloured below; the colour then began at the base of the pinnules on both sides, but more intensely on the ventral side; and on both faces of the rachis, more on the dorsal side; at length the whole rachis became red, with the exception of small patches here and there on the ventral border of the leaves.

The measurements of the three better preserved specimens are—

	A.	B.	C.
Length of the entire polypidom, ...	343 mm.	400	324
Length of the stalk, ...	?	52	48
Breadth of the stalk, ...	3	1·7	3
Breadth of the rachis, ...	2·7	1·3	1·0
Length of the base of the pinnules, . . .	6–8	4–5	4·2
Length of the ventral margin of the pinnules, .	6–8	4–5·5	4·0

Habitat.—Station 212, Philippines, lat. 6° 55′ N., long. 122° 15′ E. Depth, 10, 14, and 20 fathoms. Sand. January 30, 1875.

2. *Scytalium tentaculatum*, n. sp. (Pl. III. fig. 12, Pl. IV. fig. 13).

General appearance of *Scytalium sarsi*, in every part larger, less coloured, with a long simple tentacle at every polyp-cell.

If this form did not present the very remarkable feature of the tentaculated polyp-cells, of which fig. 13 representing a young leaf gives a very good idea, nobody would entertain a doubt of its being only a stout form of the long-known *Scytalium sarsi.* But the tentacles, which are found on every polyp-cell, and, as the younger leaves show, are developed before the polyps, make it necessary to describe it under a new name, so long as no intermediate forms between it and *Scytalium sarsi* are found. Besides this, the size of the most developed polypidom and the colour deserve attention. The largest specimen was only coloured (1) in the region of the polyp-cells, but not everywhere on all leaves, and not on all cells of the coloured leaves, and (2) on the upper part of the stalk. A second specimen was nearly colourless, with the exception of the upper end of the stalk. Two others, on the contrary, were pretty strongly coloured on the stalk, the rachis, and the base of the leaves. As a difference between the two forms I may also mention the form of the lowest undeveloped leaves. In *Scytalium tentaculatum* these form a short series, and the leaves assume very near the end the form given in fig. 13, whilst in *Scytalium sarsi* the row of these pinnules is longer, and many of them are remarkable from the fact that the polyp-cell near to the ventral surface is larger than the rest. The calcareous corpuscles are the same as those in *Scytalium sarsi*, only their maximum length is a little less on the stalk, in *Scytalium tentaculatum* 38 μ, in *Scytalium sarsi* 53 μ.

Four well-preserved specimens were at my disposal, of which I here give the following measurements :—

	A.	B.	C.	D.
Length of the whole polypidom,	620 mm.	340	330	90
Length of the whole stalk,	92	71	77	33
Length of the base of the pinnules,	12–15	6–8	6–8	8–9
Length of dorsal border,	7–9	5	5–6	5
Breadth of the stalk,	7·5	4	4	1·5
Breadth of the rachis,	3·6	2	2	2·0
Number of pinnules,	101	...	...	17

Length of the tentacles at the polyp-cells in adult leaves 0·58 mm.
Length of the tentacles at the polyp-cells in young pinnules 0·80 to 1·0 mm.

Habitat.—Station 203, Philippines, lat. 11° 7′ N., long. 123° 7′ E. Depth, 10 to 12 fathoms. Mud. October 31, 1874.

Section II. SPICATÆ.

Sub-section I. FUNICULINEÆ.

Family 2. STACHYPTILIDÆ.

Stachyptilum, n. gen.

Small pens without leaves, polyps with cells in small rows of four on both sides, and on the dorsal aspect of the rachis. Cells without stronger spines at their openings.

Zooids ventral, lateral, and dorsal on all free surfaces of the rachis; all of one kind. Stalk with a small zone of papillæ at the upper end. Axis pretty strong, round. Calcareous corpuscles of different forms, needles on the cells and zooids, lenticular bodies in the stalk, cylindrical corpuscles with three alternating ridges on each end in the tentacles of the polyps.

1. *Stachyptilum macleari*, n. sp. (Pl. VII. figs. 24–26).

Feather a little longer than the stalk, uncoloured.

Polyp-cells in fourteen rows on each side, situated on the lateral and dorsal surfaces of the rachis, the middle rows longer, with four cells, the inferior and superior shorter, with three and even only two cells. All the rows oblique, and the dorsal cells a little smaller than the ventral. Cells about 2 mm. in length, with strong needles 0·56 mm. long and 0·037 to 0·043 mm. broad in their walls; these needles project more or less at the openings of the cells, and form here and there regular spines, 1, 2, or 3 in number.

Polyps with a strong band of calcareous corpuscles in the stem of each tentacle, which are represented in fig. 26, and measure 0·027 to 0·060 mm. in length, and 0·016 to 0·028 in breadth.

The zooids are small bodies of 0·28 to 0·34 mm. in diameter, each of which is protected at its lower side by a plate of strong needles of the same kind as those of the polyp-cells. Besides these the mouth of each zooid has at its lower side a projecting two-lobed lip, which might also be described as a divided short tentacle. These zooids cover every part of the rachis which is not beset with the polyps, with the exception only of a very small line on its ventral surface. The zooids go even further down than the polyp-cells, form below the last of them about four regular rows on each side, and are also present in this region on the dorsal and ventral surface of the rachis.

The stalk has at its uppermost part a zone of about 2 mm. in length, where it is covered on its dorsal aspect, and on both sides by a crowded mass of small cylindrical papillæ of 0·17 to 0·19 mm. in length. The middle part of the stalk is whitish and the end pointed. The end of the stem contains peculiar flat, oval, or biscuit-shaped calcareous corpuscles of the length of 0·054 to 0·64 mm.

Length of the feather, ...	42 mm.
Length of the stalk, ...	32
Breadth of the feather, ...	8
Breadth of the stalk, ...	3·5
Breadth of the ventral side of rachis, ...	3·8

Habitat.—One single specimen from Station 192, south-east of Ceram, on the west of New Guinea, lat. 5° 42′ S., long. 132° 25′ E. Depth, 129 fathoms. Mud. September 26, 1874.

Family 3. ANTHOPTILIDÆ.

Anthoptilum, n. gen.

Polypidom without leaves, of the general appearance of *Funiculina*. Polyps in many short rows on the sides of the rachis, large, without cells. At the lower end of the rachis no prolonged streak of undeveloped polyps. Zooids lateral, ventral, and dorsal, all of one kind, small, wart-like. Axis round. No calcareous corpuscles, except at the end of the stalk.

1. *Anthoptilum thomsoni*, n. sp. (Pl. V. figs. 16–18).

A large, magnificent sea-pen, with a short, thick stalk, long feather, and long polyps crowded eight to ten in one row. Polyps often united at their bases. Zooids very numerous. Rachis free only on the ventral side.

Stalk with a thick swelling at the upper part, and a smaller end-bulb, with short pointed free end.

Polyps very long, without cells, and with long tentacles very seldom retracted. These polyps are disposed in many oblique rows on both sides of the rachis, so as to cover more or less completely its dorsal aspect. In the higher parts of the rachis it is quite impossible to find a free surface on this side, whilst the reverse is the case below in the neighbourhood of the stalk. On the other side the ventral surface of the rachis is free in its whole length. With regard to the position of the polyps, I have further to remark that very often the lowest parts of two, three, or more of them are united so as to produce the appearance of very small pinnules, shorter even than those of *Pavonaria finmarchica*, but in no place are all the polyps of one row united in such a manner. The tentacles of the polyps are very long, and provided with long, slender branches (pinnules), which are remarkable from their moniliform appearance (fig. 18), and the great number of small thread-cells situated in their single protuberances.

The zooids of *Anthoptilum thomsoni* are very numerous. The principal are lateral, and lie between the rows of polyps; but these lateral zooids reach everywhere the ventral surface of the rachis, and in many places the single lateral rows coalesce there so as to form genuine ventral zooids. This coalescence, however, never takes place on the greater part of the rachis, and generally coalesced lateral zooids alternate with separated sets. On the dorsal side the zooids avoid the middle line where this line is free of polyps, but where the polyps cover the whole dorsal surface the zooids are also to be found everywhere. A peculiar feature of this sea-pen is that in many places little groups of zooids reach as far as the base of the polyps themselves, and are also found between the individuals of one row. The size of the zooids is from 0·40 to 0·58 mm., and their structure the ordinary one, inasmuch as they possess two well-developed mesenteric filaments. With regard to the colour of *Anthoptilum thomsoni*, some specimens are totally uncoloured; others have all the polyps more or less brown, the stalk and rachis on the contrary colourless.

Calcareous corpuscles are only found very scantily in the muscular layer in the lowest parts of the stalk. They are small oblong bodies of 7 to 22 μ, which are often united four together so as to form small star-like figures.

The axis is round, and of the common lamelliferous and fibrous structure. Its radiating fibres are very numerous, but short.

The measurements of nine well-preserved specimens of *Anthoptilum thomsoni* are as follow:—

	A.	B.	C.	D.	E.	F.	G.	H.	I.
Length of the whole polypidom,	420 mm.	560	530	362	422	410	400	360	440
Length of the stalk, . .	65	87	75	63	67	75	65	61	57
Breadth of its enlargement, .	18	18	16	11	14	14	15	6·5	12
Breadth of the pen, . .	25	...	...	...	...	...	...	...	...
Length of the polyps with the tentacles, . . .	19	17·5	...	20	13	18	17	12	16
Length of their tentacles, .	...	6–8	...	7	9	...	...	...	...
Breadth of the rachis, . .	...	8–9	10	...	...	...	...	...	...

Habitat.—Station 320, Atlantic Ocean, south of Buenos Ayres, lat. 37° 17′ S., long. 53° 12′ W. Depth, 600 fathoms. Bottom temperature, 2°·7 C. Hard ground. February 14, 1876.

2. *Anthoptilum murrayi*, n. sp. (Pl. VI. figs. 19–21).

General appearance of *Anthoptilum thomsoni*, smaller, with smaller and less numerous polyps, two to three in each row. Polyps all sessile, widely separated from each other. Rachis without polyps in the middle line on both sides. Zooids more distant than in the last species.

Stalk long, slender, without distinct enlargement.

Polyps disposed in oblique rows of two to three, seldom four, on both sides of the rachis, which arrangement is not very apparent everywhere, all well separated from their neighbours, and the dorsal smaller than the ventral, with tentacles often far surpassing in length the bodies of the polyps.

The zooids cover the whole rachis between the polyps, and leave only the middle part of its ventral and dorsal aspect free. On the ventral side the zooids are situated on the margin and form not more than one single row, which is even interrupted here and there on the ventral side of the lowest polyps, whilst on the dorsal aspect they go nearer the middle line, and leave only a small part of the rachis free. These zooids, which in no case are situated on the bodies of the polyps as in *A. thomsoni*, measure 0·34 to 0·40 mm. in width, and their distance from one another is equal to, or greater than, their diameter. They have all two mesenteric filaments. The colour of the polypidom is pale red, the polyps brown, while the rachis and stalk are usually colourless, and present only here and there a light brown or pale rosy tint.

The axis is round, and tolerably strong.

Calcareous corpuscles in the end of the stalk oblong, of the same form and size as in *Anthoptilum thomsoni*.

The measurements of the only specimen are—

Length of the whole polypidom,	510 mm.
Length of the whole stalk,	76
Length of the lower polyps,	6–10
Length of the tentacles,	3–4
Breadth of the stalk,	3–4
Breadth of the rachis,	4–5·5

Habitat.—Station 50, North Atlantic, south of Halifax, lat. 48° 8′ N., long. 63° 39′ W. One specimen. Depth, 1250 fathoms. Bottom temperature, 2°·8 C. Grey ooze. May 21, 1873.

3. *Anthoptilum simplex*, n. sp. (Pl. IV. fig. 22).

Polypidom colourless. Polyps sessile, widely separated, very large with a broad base, two in each row. Rachis free on both sides in the middle line. Zooids numerous, more elevated than in the other two species, and somewhat conical.

Stalk with an enlargement in the upper part.

Polyps long and large, resembling in size those of *A. thomsoni*, and measuring without the tentacles 12 to 15 mm. in length. The tentacles, of which there exist only traces on some polyps, seem to have been very long. A remarkable feature is the large area of elliptical form upon which each polyp stands, and which may be regarded as a broad base to the polyp.

The zooids are to be found in the same position as in the other species, and differ only by their greater elevation on the surface of the rachis and their smaller size, as they measure only 0·28 to 0·30 mm. in diameter. The ventral zooids form a single or double series, and the dorsal a double or triple series.

Calcareous corpuscles as in the other species.

Measurement as follows:—

Length of the whole polypidom,	400 mm.
Length of the stalk,	55
Breadth of the stalk,	7
Breadth of the rachis,	4–5

Habitat.—One single specimen in a bad state of preservation, from Station 133, South Atlantic, west of Tristan d'Acunha, lat. 35° 41′ S., long. 20° 55′ W. Depth, 1500 fathoms. Bottom temperature, 1°·3 C. Globigerina ooze. October 11, 1873.

Sub-section II. JUNCIFORMES.

Family 1. Kophobelemnonidæ.

Kophobelemnon, Absjörnsen.

1. *Kophobelemnon ferrugineum*, n. sp. (Pl. XI. fig. 43).

Rachis longer than the stalk, cylindrical and pointed at the upper end, of a clear brown colour. Polyps short with broad base, retractile, at the oral side of the tentacles brown, and dark brown in their inner cavities. Zooids large, numerous, of the form of pointed warts or short spines, all obliquely directed upwards. Stalk with an end-bulb, externally of a pale grey or greenish colour, internally brown. Calcareous bodies in every part of the structure, in the form of shorter or longer slender needles, with warts and tubercles at the ends and also in the middle. Those of the stalk shorter, thicker, and more warty and spiny.

The different species of *Kophobelemnon* are not easily distinguishable so long as their structure is not thoroughly known; nevertheless, I think myself justified in separating this form from those hitherto described. Fig. 43 is sufficient to show the external form and the size of the species, and I have only to add that the longest calcareous needles of the rachis and the polyps measure 0·57 to 0·71 mm. in length and 0·052 in breadth, and the shortest on the stalk 0·09 to 0·10 mm. in length and 0·027 to 0·037 in breadth.

Habitat.—Station 232, south of Yeddo, Japan. One specimen. Lat. 35° 0′ N., long. 139° 28′ E. Depth, 345 fathoms. Bottom temperature, 5° C. Sandy mud. May 12, 1875.

2. *Kophobelemnon*, sp. (Pl. XI. fig. 44).

A young *Kophobelemnon*, with only one polyp, and a pointed end to the rachis. It resembles, by the occurrence of needles 0·54 mm. long and 0·070 mm. broad in the tentacles, my *K. stelliferum*, var. *durum*.

Zooids not numerous, in two rows on the ventral side of the rachis.

Habitat.—Station 169, north-east of New Zealand, lat. 37° 34′ S., long. 179° 22′ E. Depth, 700 fathoms. Bottom temperature, 4°·2 C. Grey ooze.

3. *Kophobelemnon burgeri*, Herkl. (Pl. XI. fig. 45).

The Challenger brought home two specimens of this rare species, which I thought right to represent in fig. 45, as their form is in some respects different from that described and figured by Herklots.

Habitat.—Station 209, Zebu, Philippines, lat. 10° 10′ N., long. 123° 55′ S. Depth, 95 to 100 fathoms. Bottom temperature, 21° F. C. Mud. January 22, 1875.

Family 2. Umbellulidæ.

Umbellula, Cuv.

1. *Umbellula durissima*, n. sp. (Pl. VIII. figs. 32, 33).

Calcareous needles very numerous in every part of the cutis. Principal needles of

the polyps and those of the tentacles of enormous length, 2·0 to 2·8 mm. Pinnules of the tentacles brown. Zooids very numerous; the ventral forming a nearly continuous plate. Rachis short, without a longer enlargement below. Stalk here and there very light brown. Axis nearly cylindrical.

Of this very remarkable species I had only one young specimen at my disposal, and it is, therefore, possible that the characters given are not fully sufficient. Nevertheless, they are of such a kind that this form can be easily distinguished from all others at present known.

The stalk has a long enlargement towards the lower end, with here and there a very slight brown tint, the seat of which is in the longitudinal nutrient canals. Its calcareous needles are extremely numerous, those of the upper part are 0·19 to 0·26 mm. long, those of the lower half are shorter and broader, and measure 0·076 to 0·20 mm. in length, and 0·019 to 0·045 mm. in breadth, all of them are warty, and have the typical three edges, but those of the lower part show the first character better, while in the others the edges are more prominent, and the surface less uneven. The breadth of the stalk is 0·58 mm. in the upper part, and 1·0 to 1·4 and 2·0 mm. towards the base.

The rachis has the aspect of a flat rhomboid expansion of the stalk, which contains the end of the axis in the middle, and bears on the dorsal side one large and two undeveloped polyps. The whole ventral surface of the rachis, with the exception only of a narrow middle line, is studded with wart-like zooids 0·28 to 0·42 mm. in size, which are also found on the dorsal side of the rachis, on a small space below and between the polyps. Two or three zooids are also found on the end of the stalk in the neighbourhood of the rachis, the lowest at a distance of 4 mm. from the great mass of zooids. All the zooids are surrounded by calcareous needles, of the same size as the smaller needles in the polyps, about 0·30 to 0·50 mm. in length.

This *Umbellula* is remarkable from the white colour of the body of its developed polyp, and of the aboral aspect of the central stems of its tentacles, while all the pinnules of the tentacles and their oral sides are of a deep brown. The white colour is occasioned by calcareous needles, the largest of which, measuring more than 2·0, even 2·85, mm. in length, and disposed in eight lines on the body of the polyp, are directly continuous with those on the stems of the tentacles. The brown colour, on the contrary, lies in the outer epithelium of the tentacles, and is brighter at the aboral side of the pinnulæ, where the epithelium is also strengthened by needles of about 0·30 to 0·34 mm. in length. The undeveloped polyps are small, pyriform bodies of 2·0 to 2·5 mm. in length without tentacles, but with large sized needles in eight rows.

The axis measures in the stalk 0·28 to 0·45 mm. in diameter. The length of the whole polypidom including the polyp, 160 mm.

Habitat.—Station 234, North Pacific Ocean, south of Yeddo, Japan, lat. 34° 7′ N., long. 138° 0′ E. Depth, 565 fathoms. Bottom temperature, 2°·3 C. Mud. June 4, 1875.

2. *Umbellula güntheri*, n. sp. (Pl. IX. fig. 34).

Exquisitely bilateral. Calcareous needles very numerous in every part of the cutis, none very large. Polyps disposed alternately, of a very light brown colour, very large, with hard thick sarcosoma. Zooids very numerous, situated on the rachis and on the stalk; those of the rachis cover every free part of it, with the exception of both middle lines; and are, therefore, ventral, dorsal, and lateral. Those of the stalk are situated in small numbers on irregular enlargements. Stalk strong, with well developed sarcasoma. Axis quadrangular, with concave surfaces and rounded edges. Of this species also I had only one imperfect specimen, which wanted the lower part of the stalk.

Stalk quadrangular, length 175 mm., broken below, where it measures 1·5 mm. in diameter. It is beset with many irregular but mostly spindle-shaped enlargements, where it attains over 2·0 mm. in width, and shows invariably in these places a certain number of zooids, of the form of those of the rachis but less prominent, all disposed irregularly, singly, in pairs or more, even eight together, and in this case all in one longitudinal line. The stalk, being broken in several places, it was impossible to make out on which side these zooids were placed, only this, that they are situated on opposite aspects, and are probably lateral. The needles of the stalk are of different sizes, longer in the upper, shorter in the lower parts. All possess very distinct edges, and besides this a granular surface. Their length is from 0·11 to 0·20 mm., and their breadth from 0·026 to 0·045 mm.

Rachis without inferior enlargement, and so evidently bilateral that it suggests a young *Kophobelemnon* with only a few polyps. The ventral side shows a direct continuation, a kind of keel, which ends with a bend or curvature where the uppermost polyp is situated. Expansions at the sides of this keel, covered with zooids, are directly continuous with the bases of the polyps, so that no other trace of demarcation exists, except that given by the zooids. On the dorsal side the rachis shows a deep groove between the polyps, which is totally covered with zooids, with the exception of a very small space in the middle line. The polyps are very large, 44 mm. long, with the tentacles extended; five well-developed, and one rudimentary, and are disposed quite regularly on both sides of the rachis in the usual alternating manner, so that the fifth developed polyp has its seat at the dorsal side of the end of the rachis. The cutis of the polyps is studded with needles, which show this peculiarity, that they are all about the same size in the same place. Those of the bodies of the polyps measure 0·27 to 0·72 mm. in length, and 0·041 to 0·045 mm. in breadth, and are in general disposed in a transverse direction. The same holds good of the needles of the principal stem of the tentacles, only these are smaller, 0·38 to 0·62 mm. in length, and 0·022 to 0·041 mm. in breadth. Those of the lateral branches or pinnules are disposed lengthways on their aboral side, and measure 0·19 mm. in length, and 0·011 to 0·020 mm. in breadth. All these needles are three-edged, and slightly granular at the end.

The zooids fill all interspaces between the polyps, and are in general conical bodies of

0·42 to 0·58 mm. in height and breadth at their bases. They are all surrounded with needles, which frequently form a kind of cell ending with several points.

Habitat.—Station 106, Atlantic Ocean, a little north of the Equator, lat. 1° 47′ N., long. 26° 46′ W. Depth, 1850 fathoms. Bottom temperature, 1°·8 C. Globigerina ooze. August 25, 1873.

3. *Umbellula thomsoni*, Köll.

(Von Willemoes-Suhm in Zeitschrift f. wiss. Zool., 1873; Kölliker in Würzburg. Verhandl., Bd. viii., 1874, and in Die Pennatulide *Umbellula* und zwei neue Typen der Alcyonarien, Würzburg, 1874, Festschrift, pp. 1–11, Taf. i. figs. 1–5.)

Indistinctly bilateral, colourless. Calcareous corpuscles in all parts of the sarcosoma. Polyps forming a pendant bunch, with a distinct rachis containing the end of the axis, which goes near the bases of the terminal polypi. Stalk quadrangular, with a well-developed lower, but no upper, enlargement. Zooids on the ventral and dorsal sides of the rachis; none on the stalk. Axis quadrangular, with excavated surfaces and rounded edges.

For further details I refer to the paper above quoted, and only adjoin here the measurements of the two specimens of this *Umbellula*.

	A.	B.
Length of the whole polypidom,	895 mm.	270
Length of the lower enlargement of stalk,	80	...
Length of the polyps,	33–39	17
Length of the bodies of the polyps,	18–20	10
Length of their tentacles,	15–19	7
Breadth of the axis,	2·5	0·7
Number of polyps,	13	5
Number of rudimentary polyps,	...	5
Length of needles of tentacles,	0·24–0·30	
Breadth of needles of tentacles,	0·021–0·032	
Length of needles of stalk at its lower end,	0·15	
Breadth of needles of stalk at its lower end,	0·064	

Habitat.—Station 7, North Atlantic Ocean, between Portugal and Madeira, lat. 35° 20′ N., long. 13° 4′ W. Depth, 2125 fathoms. Bottom temperature, 2°·0 C. Mud. January 31, 1873.

I add here some remarks on the *Umbellulæ* described by Joshua Lindahl (Om. Pennatulid slægtet *Umbellula*, Stockholm, 1874; Kongl. Svenska Vet. Akadem. Handlingar, Bd. xiii., No. 3). These *Umbellulæ*, called by Lindahl *miniacea* and *pallida*, and brought together by me (*loc. cit.*) under the name of *U. lindahli*, come very near my *U. magniflora*, but so long as we are unable to compare the different forms, it will be impossible to decide whether they are identical or not, particularly as the remoteness of the localities in which the *Umbellulæ* of Lindahl (in Baffin's Bay, lat. 70° 43′ N., long. 52° 3′ W., depth 410 fathoms; and off the entrance of

Omenakfiord, North Greenland, lat. 71° 71′ N., long. 23° 58′ W., depth 122 fathoms) and *U. magniflora* have been found militates *a priori* against their identity.

The *Crinillum siedenburgii* of Van der Hoeven is, as I have shown, the basal part of a Pennatulid, and no doubt of an *Umbellula*, as the axis has the same form as that of most *Umbellulæ*.

Habitat.—Banda Sea, lat. 6° 40′ S., long. 126° 47′ E. Depth, 2700 fathoms.

4. *Umbellula leptocaulis*, n. sp. (Pl. IX. fig. 35).

Decidedly bilateral. Calcareous needles pretty numerous in every part of the cutis, none very large. Polyps disposed alternately, of a light brown colour, large, with thin sarcosoma. Zooids scanty, on the rachis only, ventral, lateral, and dorsal. Stalk quadrangular, thin, with thin sarcosoma. Axis quadrangular, with concave surfaces and blunt edges.

Of this species I had at my disposal one smaller, perfect specimen (B), 150 mm. in length, with three polyps; and the upper part of a larger one (A), with five polyps, consisting of four fragments, and altogether 350 mm. in length.

The stalk is remarkable for its thinness. In A it measured 0·85 mm. in diameter below, and 0·34 to 0·37 mm. in its upper part. In B there was an end-bulb of 0·42 mm., and the average breadth of the rest of the stalk was 0·42 to 0·28 mm.

In the polypiferous part the ventral side shows a small, keel-like rachis, which bears the polyps on both sides, so that there is no larger free ventral space as in *Umbellula durissima* and *Umbellula güntheri*. The ventral zooids are, therefore, very few, and form only a small series on both sides of the keel. The lateral zooids are represented by a few individuals only, and the dorsal are also few in number, and disposed on a small dorsal free space between the polyps.

The polyps, 27 to 30 mm. in length in A, are thin in their sarcosoma, and show the same arrangement of the calcareous needles as in *Umbellula güntheri*, with this exception, that the needles of the tentacles are all disposed parallel to the longitudinal axis of the stems of the tentacles. The needles of the polyps in A measure 0·43 to 0·54 mm. in length, and 0·027 mm. in breadth, and those of the tentacles 0·16 to 0·21 mm. Those of the stalk measure in A 0·11 to 0·18 mm. in length, and 0·027 to 0·054 mm. in breadth; in B, 0·064 to 0·10 mm. in length, and 0·027 to 0·064 mm. in breadth. The needles in the lower part of the stem are of the common type, the shorter granulated and warty, and broader the shorter they are.

Habitat.—Station 181, South Pacific Ocean, south-east of New Guinea, lat. 13° 50′ S., long. 151° 49′ E. Depth, 2440 fathoms. Red clay. August 25, 1874.

5. *Umbellula simplex*, n. sp. (Pl. IX. fig. 36).

Decidedly bilateral. Calcareous needles numerous in every part of the cutis, none very large. Polyps disposed alternately, colourless, small, rather hard. Zooids none.

Stalk cylindrical, thin, with a moderately thick sarcosoma. Axis quadrangular, with concave surfaces and rounded edges.

The only specimen of this *Umbellula* brought home by the Challenger is evidently young. Fig. 36 gives a clear idea of its appearance, so I mention only the following details :—

The length of the whole polypidom is 108 mm., and that of the rachis with the polyps 23 mm. The polyps, four in number, are situated on both sides of a short and small rachis in such a manner that the rachis with the axis seems to enter the uppermost polyp, whilst the others lie on its sides, two on the left and one on the right side. The needles in the bodies of the polyps are disposed transversely, and measure 0·5 mm. in length and 0·030 to 0·041 mm. in breadth. Those of the tentacles are smaller, 0·27 and 0·21 mm. placed longitudinally at the aboral side of their axes and pinnules, and transversely on the oral face of the axes. All the needles are three-edged, and granulated only at their ends. The calcareous bodies of the stem are short and broad, 0·10 to 0·18 mm. long, and 0·027 to 0·054 mm. wide oblong, slightly constricted in the middle, flat, and covered with strong prominent warts.

Habitat.—Station 246, North Pacific Ocean, between San Francisco and Yeddo, lat. 36° 10′ N., long. 178° 0′ E. Depth, 2050 fathoms. Bottom temperature, 1°·3 C. Grey ooze. July 2, 1875.

6. *Umbellula huxleyi*, n. sp. (Pl. IX. fig. 37).

Indistinctly bilateral in the fully-developed state. Calcareous corpuscles none, except in the end-bulb of the stalk. Polyps forming a cluster at the end of the stalk, with traces of a bilateral arrangement, small, brown. Stalk with a long enlargement below, ending in a kind of bulb, and a large thickening at its upper end, where it appears flattened and curved in such a manner that the axis lies at the convex side. Zooids numerous on the whole stalk and between the bases of the polyps, but none on the dorsal side of the rachis between the polyps, all provided with one single tentacle. Axis indistinctly quadrangular.

The Challenger brought home four specimens of this curious form, which being different in size and age, gave me an insight into the development of the polypiferous part.

Two younger specimens had four and five polyps. One of these may be named the terminal polyp, as the axis ends in its body, and in one specimen reaches even as far as the line of attachment of the tentacles. Of the other polyps, two, which may be termed the lateral polyps, are placed below and on the sides of the terminal polyp, and the rest (one or two), which I call the dorsal polyps, on the dorsal side of the lateral polyps.

Of the more developed specimens, one had seven more or less developed polyps,

five small ones, and three wart-shaped and undeveloped. The terminal polyp was bent in such a manner that it lay apparently at the dorsal side of the two uppermost lateral polyps. Then succeeded three well-developed lateral polyps on the right side, and on the left only one smaller. The dorsal polyps were six in number, five of which had tentacles, but were small, the sixth being only rudimentary. Other two rudimentary polyps were placed at the ventral side of the right lateral lower individuals.

The best developed polypidom of all (fig. 37) showed in the middle on its ventral side the terminal polyp in which the axis was not visible with the exception of its end. Two large lateral polyps appeared on both sides, and between these and the terminal individuals, but on the ventral side of the lateral, five young polyps and a rudimentary one, the position of which is well shown by the figure. On the dorsal side four pretty well-developed polyps lay between the lateral ones, two larger in the middle, one above the other, and two smaller at the sides. Besides these, two very small polyps were situated between the left dorsal, the left lateral, and the terminal polyp, and two rudimentary ones at the same place on the other side.

Taken altogether, we may say that in the younger specimens the polyps show a regular bilateral arrangement. A terminal and two lateral polyps are the first expression of it. Then new buds arise, first on the dorsal, and then on the ventral side, and these are in part also decidedly bilateral. But such buds seem likewise to grow on the dorsal middle line, which fact would alter the symmetry. It may, however, be supposed that these are also in reality lateral, and that the polyps of *Umbellula* are essentially disposed in series on both sides of the rachis, which arrangement is veiled by the shortness of their seat of attachment.

The polyps of *Umbellula huxleyi* are dark brown in their upper parts and lighter below; they have the tentacles shorter than the bodies of the polyps, and regularly beset with short pinnulæ. A peculiar fact which was new to me is, that these polyps are retractile, but this retraction takes place very seldom, and was only to be seen in one specimen.

The stalk is somewhat rich in sarcosoma, especially at its enlargements, and shows only faint traces of colour, both ends being pale. Its most remarkable feature is the arrangement of the zooids, which are most numerous on the upper enlargement, which they cover on every side, with the exception only of the dorsal and ventral middle line. From this point, the zooids throng to the polypiferous portion and pass on to the terminal polyp nearly as far as the axis, whilst they end at the bases of the other polyps entering for a certain distance in the spaces which separate them. In the interior of the bunch of polyps no zooids are present.

The zooids just mentioned are visible to the naked eye, but the microscope is required to ascertain that, as in the *Umbellula güntheri*, they are also present on the remainder of the stalk and even on its lower enlargement. As far as I could ascertain without destroy-

ing the best specimen, they diminish gradually in number, and form a little below the middle of the stalk, one row only on each side, the individuals of which are 1·5 to 1·7 mm. apart.

The zooids of this *Umbellula* are large, 0·22 to 0·34 mm. in diameter, and have all one cylindrical tentacle, 0·28 to 0·58 mm. long, and 0·057 to 0·085 to 0·014 mm. broad. These tentacles were found in a very good state of preservation on the largest specimen, whilst the others did not show them at all, or only traces of them. I presume that they were not yet developed in the younger specimens; or that they are easily lost or not easily seen in certain cases because they are retractile.

Calcareous corpuscles of oblong form, with even surfaces, are only found in the muscular layers of the lowest part of the lower enlargement of the stalk. Their maximum length and width is 26 μ and 8 μ.

Size of the four specimens in millimeters—

	A.	B.	C.	D.
Length of the whole, ...	107 mm.	153	160	180
Length of the polypiferous part, . . .	12	11[1]	19	16
Length of the upper enlargement of the stalk, .	8	10	30	41
Breadth of the same, ...	1·5	1·5	3	2·5
Length of the lower swelling, ...	19	23	31	34
Breadth of the same, ...	1	2·3	1·9	2·5
Length of the polyps, ...	01	...	17	13

Habitat.—Station 235, North Pacific Ocean, south of Yeddo, lat. 34° 71′ N., long. 135° 39′ E. Depth, 565 fathoms. Bottom temperature, 3°·3 C. Mud. June 4, 1875.

7. *Umbellula carpenteri*,[2] n. sp. (Pl. X. figs. 38–40).

Indistinctly bilateral in the fully-developed state. Calcareous corpuscles only in the lowest part of the stalk. Polyps forming a rosette at the end of the stalk, long, colourless. Stalk with an enlargement at its upper end, which is directly continuous with the club-shaped rachis, and having a long enlargement at its lower end. Stalk here and there, but not in all specimens, with brown-red streaks and patches. Zooids numerous on the dorsal and ventral sides of the rachis, and along the whole stalk; all provided with one singly branched tentacle. Axis quadrangular, with deeply excavated surfaces and rounded edges.

Five specimens of this *Umbellula* showed a very interesting gradation from a bilateral to an apparently irregular arrangement of the polyps. One terminal and two lateral polyps are shown in fig. 39, *A*, *B*. Four polyps all lateral, with a free end of the rachis are visible in fig. 39, *C*. A third specimen had one terminal polyp, two lateral on the right and one only on the left side. In a fourth there were eight polyps, of different sizes, so disposed that they formed a rosette surrounding a small dorsal area of the rachis of a stellate

[1] Tentacles retracted.

[2] Named after my old friend Dr W. B. Carpenter, C.B., F.R.S.

form, but amongst these polyps the terminal one was easily recognisable, as the axis ended in its base, and the other seven could be interpreted as lateral polyps arising from a shortened rachis. The fifth specimen finally showed eight polyps, arranged in the form of a rosette, and surrounding like a cup a ninth middle polyp; but this was not the terminal one in which the axis ended, one of the eight had this signification.

The stalk has at its lower end a small bulb, which is continuous with a long enlargement, the transverse section of which is very evidently quadrangular. At the upper end the stalk begins again to enlarge at a certain distance from the polyps, and forms a club-shaped swelling directly continuous with the rachis. At this point the ventral surface is convex from right to left, whilst the dorsal aspect is flat or slightly concave. The whole upper swelling is also generally curved longitudinally, convex on the ventral, concave on the dorsal side.

The zooids show the same arrangement as those of *Umbellula huxleyi;* the only differences are, (1) that zooid-like bodies are situated between the polyps of the dorsal side of the rachis, (2) that their tentacles, the length of which is 0·3 to 0·5 mm., are generally, but perhaps not in every case, provided with two to three branchlets, and (3) that the zooids seem to be fewer on the lowest part of the stalk. The calcareous corpuscles of the end-bulb are of the same kind as those of *Umbellula huxleyi* but smaller, scarcely surpassing 15 μ in length.

	A.	B.	C.	D.	E.
Length of the whole polypidom, . .	51·5 mm.	105	280	393	485
Length of the polypiferous part, . .	5	16	...	47	...
Length of the polyp bodies, . . .	7·5	11	15	16	14
Length of the polyps with tentacles, . .	...	...	43	...	83
Breadth of the upper swelling of the stalk, .	...	...	5·5	3	6
Breadth of the lower swelling of the stalk, .	...	...	2·0	2·3	3·5
Breadth of the stalk in the middle, . .	...	...	0·6	1·0	1·3

Habitats.—Station 156, South Polar Sea, south-west of Australia, lat. 62° 26′ S., long. 95° 44′ E. Depth, 1975 fathoms. Diatomaceous ooze. February 26, 1874.

Station 157, lat. 53° 55′ S., long. 108° 55′ E. Depth, 1950 fathoms. Diatomaceous ooze.

8. *Umbellula magniflora,* n. sp. (Pl. XI. figs. 41, 42).

General appearance of *Umbellula huxleyi.* Polyps forming a bunch at the end of the stalk, without any trace of bilateral arrangement, and no distinct rachis. Stalk with a long swelling below, and a flattened and curved enlargement at its upper end. Zooids numerous on the upper enlargement of the stalk at the bases of the polyps, and also on the lower swelling of the stalk and in its neighbourhood. Calcareous bodies none. Axis quadrangular, with concave surfaces and rounded edges.

The only specimen of this *Umbellula* brought home by the Challenger is in a very bad state of preservation; nevertheless it is of great interest, as it is the only known *Umbellula* which resembles the *Umbellula* of Ellis and Mylius so much that it seems to be the same species, or at least to come very near it. The lower enlargement of the stalk is cylindrical below, and ends in a small bulb, in which the pointed end of the axis is contained. The upper portion of the lower swelling is quadrangular, of the same form as the axis, and larger than the lower portion. From the top of this swelling the stalk diminishes gradually in thickness, assuming its smallest diameter about the middle of the whole length, and enlarges slowly upwards, forming finally the upper enlargement at a short distance below the polyps. The upper swelling is flattened nearly to the point where the polyps are attached, and only in their immediate neighbourhood becomes more cylindrical, so as to form a kind of short peduncle for their attachment.

The polyps form a compact bunch, and seem to be placed all on one level. On a closer inspection the axis is seen to run into the base of one of them, and here a kind of short rachis is formed, which, however, is very different from the ordinary structures of this kind. The real arrangement of the polyps is such that the nine polyps visible from the outside surround a small inner area, which may be regarded as the dorsal side of the rudimentary rachis, and from the middle of this space one single full-grown central polyp arises, surrounded at its base by large wart-like zooids, which I am inclined to interpret as rudimentary polyps.

The zooids are very numerous on the upper part of the flattened enlargement, and leave only the two middle lines free. They then advance towards the bases of the polyps in such a manner as to form four pointed areas corresponding to the interspaces between them. These pointed areas, which are visible to the naked eye, appear to have been seen also by Ellis, and are figured by him at letter *N*. On the lower part of the upper enlargement of the stalk the zooids become less numerous, and, so far as I have been able to ascertain, they at length disappear, but they reappear on the lower swelling of the stalk and in its neighbourhood, where they seem to be pretty numerous, and to be arrayed in longitudinal lines. But I am not in a position to clear up totally their relations, as I could not destroy the only specimen of this interesting form.

The colour of this *Umbellula* is different shades of brown.

Length of the whole,	740 mm.
Length of the polypiferous portion,	50
Length of the upper swelling of the stalk,	85
Breadth of the upper swelling of the stalk,	7
Length of the lower swelling,	77
Breadth of the lower swelling,	6
Breadth of the stalk in the middle,	1·3–1·5
Length of the polyps,	45
Length of the tentacles of the polyps,	19
Length of the bodies of the polyps,	26

Habitat.—Station 147, South Sea, east of Kerguelen Island, lat 46° 16′ S., long. 48° 97′ E. Depth, 1600 fathoms. Bottom temperature, 0°·8 C. Globigerina ooze. December 30, 1873.

A fragment of an *Umbellula* in two pieces, dredged at Station 146—lat. 46° 46′ S., long. 45° 31′ E.; depth, 1375 fathoms; bottom temperature, 1°·5 C.; globigerina ooze—seems to belong to *Umbellula magniflora.* The principal argument in favour of this supposition, besides the habitat, is that the lower swelling of the stalk shows zooids as in that species, which are so well developed that I thought it right to show them in fig. 12. The upper part of the stalk is in so bad a condition that not a single polyp is preserved, so that nothing can be said of these parts. The length of both fragments, 251 mm.; breadth of the lower swelling of the stalk, 0·83 mm.; of the thinner part of the stalk, 0·42 mm.; diameter of zooids, 0·17 to 0·19 mm.

Family 3. Protocaulidæ.

Protocaulon, n. gen.

Sea-pens of the group of the Protocauleæ. Polyps sessile, without cells, disposed alternately on each side of the rachis in one single row. No calcareous corpuscles.

1. *Protocaulon molle*, n. sp. (Pl. VII. fig. 23).

The whole pen 26 mm. long. Stalk, 15 mm. long, 8·28 mm. thick, with the exception of the lower half, which has a maximum thickness of 0·57 mm. Rachis, 0·26 mm. Polyps, fourteen in number, four of which are rudimentary, with the partially retracted polyps not much longer than 0·58. Zooids (?). I think I have seen one zooid below each polyp, but as I could not destroy the only specimen of this sea-pen, this point was not ascertained. Axis round, 0·11 mm. thick, with shorter stout radiating fibres. Generative organs in the more developed polyps.

Habitat.—Station 169, north-east of New Zealand, lat. 37° 34′ S., long. 179° 22′ E. Depth, 700 fathoms. Bottom temperature, 4°·2 C. Grey ooze. July 10, 1874.

Family 4. Protoptilidæ.

Microptilum, n. gen.

Sea-pens of the family of the Protoptilidæ. Polyps with cells, sessile, disposed alternately on each side of the rachis in one single row. Cells triangular, with one strong spine on their ventral side. Zooids small, one single individual at the base of each cell on its ventral side. Axis round. Calcareous corpuscles in the rachis, the stalk, the cells, and the tentacles of the polyps.

1. *Microptilum willemöesi*, n. sp. (Pl. VII. fig. 27).

Small, rachis longer than the stalk. Stalk with very inconspicuous swellings. Polyp-cells of two kinds, larger and smaller; the larger, 2·8 to 3·4 mm. in length, alternate pretty regularly with the smaller, the size of which is about 0·8 mm., and which are to be regarded as belonging to developing polyps. Number of larger cells 12; underneath the lowest, three smaller cells follow, visible with the naked eye, and three or four zooid-like undeveloped polyps, which are only to be seen with the microscope. The polyps are the only coloured parts of the polypidom, and have brownish stomachs, while the rest of their bodies has a yellowish tint.

Zooids flat, oval, 0·37 mm. long, without spines.

Calcareous corpuscles of the form of needles, 0·86 mm. long on the rachis, and decreasing to from 0·080 to 0·14 mm. and less on the stalk.

Rachis broad, 0·70 mm.

Stalk 0·45 to 0·48 mm.

Length of the whole polypidom 65 mm., of the stalk 25 mm.

Habitat.—One single specimen from Station 235, south of Yeddo, lat. 34° 7′ N., long. 138° 0′ E. Depth, 565 fathoms. Bottom temperature, 3°·3 C. Mud. June 4, 1875.

Leptoptilum, n. gen.

Sea-pens of the family of Protoptilidæ. Polyps with cells, sessile, disposed alternately in one single row on each side of the rachis. Cells cylindrical, with eight long spines. No real zooids, but a certain number of rudimentary polyps between each pair of the full-grown individuals. Axis round, pointed, and straight at both ends. Calcareous corpuscles in the stalk, rachis, the cells, and the tentacles of the polyps

1. *Leptoptilum gracile*, n. sp. (Pl. VII. fig. 28).

Small, rachis longer than the stalk.

Stalk with a small enlargement at its upper end, and a little end-bulb.

Polyp-cells 2 to 3 mm. long, and 0·85 mm. broad, with eight well-developed spines at their opening, but disposed in such a manner that many of them appear to be opposite, which is in reality nowhere the case. Another peculiar feature is that the size of the polyp-cells does not decrease regularly towards both ends of the rachis, as is usually the case, but that in the centre smaller and larger cells are found without any rule in their distribution.

The polyps are the only coloured part of this sea-pen, their stomachs being brown, and the other parts yellow. The axis of the tentacles bears a row of calcareous needles 0·11 mm. in length.

The rudimentary polyps lie two to five in number, and 0·16 to 0·32 mm. and upwards in size, between each pair of developed polyps. They possess similar cells, but

the tentacles are simple and have no calcareous needles. Between these rudimentary individuals and the full-grown polyps many intermediate stages may be found, and I have no doubt that this sea-pen grows not only at the end, but also by the formation of new individuals between the old ones.

The calcareous corpuscles are very numerous in the cells, and in the integument of the rachis, and have the form of long needles 0·35 mm. and upwards in length. On the stalk the needles are also very numerous, but they diminish gradually in size, and measure only 38 to 58 μ in its lower parts. In the end-bulb itself the muscular layer contains the same small oval bodies of 3 to 15 μ, which have been described in the genus *Anthoptilum.*

In the axis radiating fibres are wanting, and are represented by the same oval plates, which I have described in other Pennatulida.

Measurement of the largest specimen—

Length of the whole, ...	75 mm.
Length of the stalk, ...	23
Breadth of the stalk above and below, ...	0·58
Breadth of the rachis, ...	0·23–0·34
Breadth of the axis, ...	0·20

Habitat.—Several well-preserved specimens from Station 169, north-east of New Zealand, lat. 37° 36′ S., long. 179° 24′ E. Depth, 700 fathoms. Bottom temperature, 4°·2 C. Grey ooze. 10th July 1874.

Protoptilum, Köll.

1. *Protoptilum aberrans*, n. sp. (Pl. VIII. fig. 30).

General appearance of *Protoptilum carpenteri*, Köll. Polyps larger, disposed in one row only on each side of the rachis. Polyp-cells truncate at their upper end, without spines. Zooids dorsal, lateral, and ventral, larger than in *Protoptilum carpenteri.* Rachis with a swelling in which the sexual products are found, in the lower part, in the region of the undeveloped polyps.

Polyps disposed, partly alternately, partly nearly opposite, forming in general a single row on each side, but in some places showing a tendency to an arrangement in series of two; polyp-cells of the form of a cornucopia, 2·85 mm. long, and 1·14 mm. wide at the opening. Zooids of the form of the polyp-cells, 0·57 to 1·0 mm., with cells like the polyps. The number of zooids is much more numerous than that of the polyps, and they are placed without any apparent rule except at the lowest, thickest part of the rachis, where the zooids alternate with the here rudimentary polyps in such a manner that one dorsal and one ventral zooid is placed between two polyps.

Rachis, 0·85 mm. broad in the upper parts, increasing below to 1·7 mm. and 2·0 mm.

Colour of the cells of the polyps and zooids light red, and of the stems of the tentacles of the polyps pale red, which colour is occasioned by red calcareous needles. Besides these, colourless needles occur in all uncoloured parts of the rachis, and in the stems of the tentacles at their ends.

Axis cylindrical, 0·37 mm.

Habitat.—One single specimen from Station 44, North Atlantic, south of New York, lat. 37° 25′ N., long. 71° 40′ W. Depth, 1700 fathoms. Bottom temperature, 1°·7 C. Grey ooze. May 2, 1873.

2. *Protoptilum*, sp.

A fragment of a *Protoptilum* differing from *Protoptilum aberrans*, (1) by the more intense colour of the cells, (2) by the longer row of undeveloped polyps, (3) by the occurrence of only dorsal and ventral zooids, (4) by the smaller size of the polypidom, (5) by the more intense colour of the needles of the stems of the polyps, (6) by the absence of a swelling at the lower part of the rachis.

The fragment in question consists of a stalk, which has an upper swelling, and a large end-bulb.

Habitat.—Station 45, North Atlantic, south of New York, lat. 38° 34′ N., long. 72° 10′ W. Depth, 1240 fathoms. Bottom temperature, 2°·4 C. Mud. May 3, 1873.

3. *Protoptilum*, sp.

A second fragment comes nearer to *Protoptilum aberrans*, and differs from it only in the want of colour of the needles in the tentacles of the polyps, and in the absence of generative organs in the swelling of the rachis.

Habitat.—Station 46, North Atlantic, east of New York, lat. 40° 17′ N., long. 66° 48′ W. Depth, 1350 fathoms. Bottom temperature, 2°·3 C. Mud. May 6, 1873.

Trichoptilum, n. gen.

Sea-pens of the family of the Protoptilidæ. Polyps with cells, sessile, disposed alternately in one single row on each side of the rachis. Cells cylindrical, with eight strong spines. Zooids dorsal, one to three between the polyps, small, without spines. Axis quadrangular. Calcareous bodies numerous in the cells and tentacles of the polyps, very scarce in the sarcosoma of the rachis, abundant in that of the stalk.

1. *Trichoptilum brunneum*, n. sp. (Pl. VIII. fig. 31).

Long and slender. Rachis more than five times the length of the stalk. Length of rachis, 29 mm. of stalk, 5·3 mm. Stalk, with an upper enlargement of 1·6 mm. and an end-bulb of 2·6 mm. diameter, with short calcareous needles of 42 to 68 μ, which are very numerous in the upper parts, and diminish in number towards the end-bulb.

The polyps begin below with a long row of undeveloped individuals the real length of which cannot be ascertained owing to the bad state of preservation of this part of the polypidom. The developed polyps measure 1·2 to 3·2 mm. in length, are rather crowded, and so placed that smaller and larger are intermingled without any rule. Colour of the polyps brown, with the exception of the tentacles which are colourless, and contain calcareous needles of 0·15 mm. in length. Polyp-cells with strong colourless needles of 0·5 mm.

Rachis quadrangular, 0·76 mm. broad, brown on all four sides, from the colour of the epithelium of the longitudinal canals. Sarcosoma in small quantity, with some needles in its dorsal side.

Habitat.—One single specimen from Station 192, south-east of Ceram, west of New Guinea, lat. 5° 42′ S., long. 132° 25′ E. Depth, 129 fathoms. Mud. September 26, 1874.

Scleroptilum, n. gen.

Sea-pens of the family Protoptilidæ. Polyps without cells, sessile with broad bases, disposed on each side of the rachis in a single row. Zooids dorsal, apparently in one row. Axis round. Calcareous corpuscles of large size, abundant in the polyps and their tentacles, and in the sarcosoma of the rachis; those of the stalk numerous, but smaller.

1. *Scleroptilum grandiflorum*, n. sp. (Pl. VII. fig. 29).

Calcareous corpuscles in the smaller branches of the tentacles very few in number. Polypidom of medium size, uncoloured. Rachis longer than the stalk. Stalk, with an upper swelling, and an end-bulb. Polyps usually disposed in pairs, apparently opposite, while, on a closer inspection, it becomes evident that the two polyps of a pair never lie on the same level; nevertheless, regular alternation does not take place, the more so as in many places a single polyp is interposed between two pairs. The intermediate polyps, which are smaller than the others, may be looked upon as indications of new developing pairs, as we have seen that in several genera of the *Protoptilidæ* young polyps are developed between the old ones.

The single polyps are large and hard and stiff, from the great number of strong calcareous needles in their sarcosoma. Their length is about 5 mm.,—with extended tentacles, 6 mm.; and their breadth at the base 3 mm., and higher up, just below the tentacles, 1·5 mm. Nearly all are curved in such a manner that the tentaculiferous part is bent upwards; in some instances the curve is even stronger, and then the tentacles look towards the stalk.

The zooids measure at their base 0·42 mm., and are small conical prominences, with an elevation of not more than 0·2 mm. They are all dorsal, and form one single row, which is so disposed that one portion lies on the right, and the other on the left of the

dorsal middle line. Their number is so small that it does not much surpass that of the polyps.

The rachis is cylindrical, with very little sarcosoma.

The axis is round, and measures in the lower part of the rachis 0·9 mm. in diameter.

The maximum length of the calcareous needles is 0·70 to 0·74 mm., and the breadth 0·14 mm. In the tentacles, needles of 0·40 to 0·45 mm. run up the aboral side of the stem, forming a strong axis, and two or three smaller needles are found in the base of each secondary tentacle. In the sarcosoma of the stalk and the rachis itself the needles are shorter and more slender, and go down to a size of 0·085 to 0·14 mm. in length, and 0·028 mm. in breadth.

Of three specimens of this sea-pen only one was entire, the second wanted the stalk, and the third the end of the rachis.

	A.	B.	C.
Length of the whole polypidom, ...	100 mm.	...	...
Length of the rachis, ...	62	140	...
Length of the stalk, ...	38	...	51·5
Upper swelling of stalk, ...	1·7	...	2·0
Upper swelling of end-bulb, ...	1·3	...	2·5

Habitat.—Station 241, North Pacific, east of Japan, lat. 35° 41′ N., long. 157° 42′ E. Depth, 2300 fathoms. Bottom temperature, 1·1° C. Red clay. June 23, 1875.

2. *Scleroptilum durissimum*, n. sp.

All smaller branches of the tentacles studded with calcareous corpuscles.

The Challenger collection contains only one imperfect specimen of this form, which comes very near *Scleroptilum grandiflorum*. The principal differences are the following :—

a. The polyps are smaller.

b. The smaller branches of the tentacles possess in their whole length at their aboral side a strong axis or train of needles of 0·054 mm. in length.

c. The needles of the sarcosoma of the polyps are a little shorter (0·28 mm. in length, 0·085 mm. to 0·11 in breadth).

d. The needles of the sarcosoma of the rachis are more numerous and longer.

Habitat.—Station 235, North Pacific, south of Yeddo, lat. 30° 7′ N., long. 138° 0′ E. Depth, 564 fathoms. Bottom temperature, 3°·3 C. Mud. June 4, 1875.

Section II.—RENILLEÆ.

Renilla, Lam.

1. *Renilla mülleri*, M. Schultze (Pl. XI. fig. 46).

The Challenger brought home a great number of this *Renilla*, of which I give in fig.

46 a more characteristic representation than those contained in my monograph of the Pennatulidæ.

Habitat.—Station 321, off Buenos Ayres, lat. 35° 2′ S., long. 55° 15′ W. Depth, 13 fathoms. Mud. February 25, 1876.

Section. III.—VERETILLEÆ.

Family 1. Cavernularidæ.

Cavernularia, Val.

1. *Cavernularia obesa*, Val.

Habitat.—Station 163*a*, off Port Jackson, Australia. Depth, 30 to 35 fathoms. June 3, 1874.

This *Cavernularia*, of which I had two specimens, is in its exterior forms so like *Clavella australasiæ* with which it was collected that it was necessary to investigate the calcareous corpuscles in order to distinguish them.

Family 2. Lituaridæ.

Lituaria, Val.

1. *Lituaria phalloides*, Pall. (?)

One single specimen of a *Lituaria* dredged by the Challenger agrees pretty well with *Lituaria phalloides*. Nevertheless, it differs in the following points, and may perhaps in future, when both *Lituariæ* are better known, be recognised as a new species :—

1. The sarcosoma of the bodies of the polyps is much thinner than in *Lituaria phalloides*, and contains some calcareous corpuscles.
2. The tentacles also contain some, but very few calcareous bodies.
3. The axis is provided with two excavations only at its uppermost part.
4. The calcareous bodies are furnished with longer excrescences and branches at their ends.

Habitat.—Station 233*a*, Kobi, Japan, lat. 34° 35′ N., long. 135 10′ E. Depth, 8 to 50 fathoms. Mud, sand. May 17–19, 1875.

Clavella, Gray.

1. *Clavella australasiæ*, Gray.

Of this rare Pennatulid the Challenger brought home two well-preserved specimens and several fragments. They agree with the typical form with this exception only, that the axis passes in some specimens very nearly to the lower end of the stalk.

Habitat.—Station 163*a*, off Port Jackson, Australia. Depth, 30 to 35 fathoms. Rock. June 3, 1874.

General Remarks.—After having described the Pennatulida collected by the Challenger, which consist of at least thirty-eight species and nineteen genera, amongst which seven genera and twenty-seven species are new to science, I think it right to conclude with some general remarks.

First of all I wish to propose a new systematic arrangement of the Pennatulida, as the one given by me in my monograph (pages 14, 295, and 436) has become incomplete in consequence of the newly-discovered forms and the addition to our knowledge derived from their study. The system I now propose is the following:—

Order PENNATULIDA.

I. Rachis with a bilateral arrangement of the polyps.

A. Rachis elongated, cylindrical.

AA. With pinnules or leaves.

Section I. PENNATULEÆ.

Pinnules well developed.

Sub-section I. PENNIFORMES.

Zooids situated on the pinnules.

Family 1. Pteroeididæ.

Genera *Pteroeides*, Herkl.
Godefroyia, Köll.
Sarcophyllum, Köll.

Zooids on the ventral and lateral sides of the rachis.

Family 2. Pennatulidæ.

Genera *Pennatula*, Lam.
Leioptilum, Verr.
Ptilosarcus, Gray.
Halisceptrum, Herkl.

Pinnules small.

Sub-section II. VIRGULARIEÆ.

Pinnules without a calcareous plate.

Family 1. Virgularidæ.

Genera *Virgularia*, Lam.
Scytalium, Herkl.
Pavonaria, Köll. (sp. *P. finmarchica*).

Pinnules with a calcareous plate.
Family 2. STYLATULIDÆ.

Genera *Stylatula*, Verr.
Dubenia, Kor. and Dan.
Acanthoptilum, Köll.

BB. Rachis without pinnules, polyps sessile.
Section II. SPICATÆ.

a. Polyps on both sides of the rachis in distinct rows
Sub-section I. FUNICULINEÆ.

aa. Polyps with cells.

α No ventral zooids.
Family 1. FUNICULINIDÆ.

Genera *Funiculina*, Lam. (sp. *F. quadrangularis*).
Halipteris, Köll. (sp. *H. christii*).

β. With ventral zooids.
Family 2. STACHYPTILIDÆ.
Genus *Stachyptilum*, Köll.

bb. Polyps without cells.
Family 3. ANTHOPTILIDÆ.
Genus *Anthoptilum*, Köll.

b. Polyps on both sides of the rachis in a single series or in indistinct rows.
Sub-section II. JUNCIFORMES.

aa. Polyps without cells.
α. Polyps large.
αα. Rachis elongated, cylindrical.
Family 1. KOPHOBELEMNONIDÆ.

Genera *Kophobelemnon*, Asb.
Sclerobelemnon, Köll.
Bathyptilum, Köll.

ββ. Rachis short.
Family 2. UMBELLULIDÆ.
Genus *Umbellula*, Lam.

β. Polyps small.

Family 3. Protocaulidæ.

Genera *Protocaulon*, Köll.
Cladiscus, Kor. and Dan.

bb. Polyps with cells.

Family 4. Protoptilidæ.

Genera *Protoptilum*, Köll.
Lygomorpha, Kor. and Dan.
Microptilum, Köll.
Leptoptilum, Köll.
Trichoptilum, Köll.
Scleroptilum, Köll.

B. Rachis expanded in the form of a leaf.

Section II. RENILLEÆ.

Family 1. Renillidæ.

Genus *Renilla*, Lam.

II. Rachis with a radiating arrangement of the polyps.

Section III. VERETILLEÆ.

Calcareous bodies long.

Family 1. Cavernularidæ.

Genera *Cavernularia*, Val.
Stylobelemnon, Köll.

Calcareous bodies short.

Family 2. Lituaridæ.

Genus *Lituaria*, Val.
Veretillum, Cuv.
Policella, Gray.
Clavella, Gray.

With regard to the Geographical Distribution of the Pennatulida the new forms of the Challenger Expedition are of great interest, and confirm and extend the conclusion at which I arrived in my monograph.

As to their *horizontal* distribution, I wish to point out first of all the interesting fact that the Challenger Expedition seems to prove that the Pennatulida are not distributed

over all seas in a regular manner. Over great tracts the Challenger did not find a single specimen of this order; for instance, in the Atlantic, between Buenos Ayres and Cape Finisterre (Stations 322 to 354), between the Canaries and the West Indies (Stations 1 to 42), between Bermuda, Madeira,[1] and the Cape de Verde Islands,[2] till near the Equator (Stations 58 to 105).

One *Umbellula* was found at Station 106,[3] and then nothing across the Atlantic to Cape St Roque, along the coast to Bahia, and again back across the Atlantic to Station 132, near Tristan d'Acunha. Nothing again on the way to the Cape of Good Hope, and up to Stations 146 and 147, where two *Umbellulæ* were found. From Station 147 to Melbourne, through the South Polar Sea, two *Umbellulæ* were dredged at Stations 156 and 157. No Pennatulidæ were found between Australia and New Zealand (Stations 164 to 168), none between these islands, past the Fiji and New Hebrides groups, to New Guinea (Stations 170 to 180), none between the Philippines and New Guinea, and thence to Japan (Stations 213 to 231), only two forms, an *Umbellula* and a *Scleroptilum* between Japan and the Sandwich Islands, and nothing from Hawaii through the whole Pacific Ocean to Valparaiso, through the Straits of Magellan, past the Falkland Islands to near Buenos Ayres (Stations 237 to 239).

It seems, therefore, reasonable to conclude, so far as our present knowledge goes, that the deeper portions of the Pacific and the Atlantic Oceans, and the South Polar Sea, contain very few or none at all of the Pennatulida at a certain distance from the shore.

I may add that Professor T. H. Studer, of Bern, who went with the German ship "Gazelle" round the world, and dredged in a good many places, found only six Pennatulida, which is the more worth mentioning as he dredged especially in shallow water and along the shore.

As to the horizontal distribution of the families of the Pennatulida, the following may be remarked:—

As I showed in my monograph, the Pteroeididæ have a well-defined centre in the south-east coasts of Asia, the Sunda Islands, and the Philippines, from which they spread, with few forms, as far as Japan, Australia, New Guinea, New Caledonia, the Carolines, the west coast of Africa and the Red Sea; *Pteroeides griseum* of the Mediterranean being quite an exception. The results of the Challenger confirm these data, as they make only three Pteroeididæ from the Philippines, Australia, and Japan.

The Pennatulidæ, on the contrary, have a wide distribution along the coast of Europe, the west coast of North America, the coasts of China, Japan, India (south-east coast), Australia, New Guinea, Africa (east coast). No Pennatulidæ are known from the east coast of North America, the west coast of South America, nor the west coast of

[1] Studer found at Madeira, *Cavernularia madeirensis*.

[2] Studer found here *Veretillum cynomorium*, var. *astyla*.

[3] Studer found an *Umbellula* and *Pavonaria africana*, Stud., near Station 97.

Africa. The Challenger found five new forms of Pennatulidæ from Australia, New Guinea, the Philippines, and Japan, amongst them four species (*Pennatula moseleyi, murrayi, naresi,* and *pearceyi*) which are nearer the known European types, and only one species with the soft leaves of the typical Asiatic and west American forms (*P. sulcata*).

The knowledge of the VIRGULARIDÆ has been augmented by the discovery of the habitat of *Scytalium sarsi* (Philippines), and the discovery of a new *Scytalium* from the same locality. The Virgularidæ, as I now define them, are widely distributed in the European seas (three species of *Virgularia,* two of *Dubenia*), the east and west coasts of America (all the species of *Stylatula* and of *Acanthoptilum*), the east coast of Africa (*Pavonaria africana,* Stud.), and the south-east Asiatic seas, as far as Australia (eight species of *Virgularia,* two of *Scytalium*).

The STACHYPTILIDÆ, PROTOCAULIDÆ, and PROTOPTILIDÆ, belonging to the simplest forms of the Pennatulida, have two centres, one in the Pacific Ocean, on the coasts of New Guinea (*Stachyptilum, Trichoptilum*), New Zealand (*Protocaulon, Leptoptilum*), and Japan (*Scleroptilum, Microptilum*), and one in the North Atlantic (*Protoptilum*), and North Sea (*Lygomorpha, Cladiscus*).

The ANTHOPTILIDÆ are limited to the east coast of America, but have a wide range from Halifax to Buenos Ayres and Tristan d'Acunha.

With regard to the KOPHOBELEMNONIDÆ, the VERETILLIDÆ, and the RENILLIDÆ, little new has been added to our knowledge through the investigations of the Challenger, with the exception of a new *Kophobelemnon* from Japan. Nevertheless, it is interesting to know that the limited distribution of these families has been confirmed. Professor Studer has lately found a *Veretillum* at the Cape de Verde Islands, and a *Cavernularia* at Madeira.

The distribution of the UMBELLULIDÆ is most remarkable. After having known for more than a century only one locality, the North Polar Sea, near the coast of Greenland, we have now learned that this form is far and widely distributed. *Umbellulæ* have now been obtained from the North Atlantic Ocean (between Portugal and Madeira); from the North Polar Sea, coast of Greenland; from the Atlantic Ocean, under the Equator, between Africa and America, and from the west coast of Africa, north of Sierra Leone (Stud.); from the South African Sea, west of Kerguelen Island; from the South Polar Sea; from the coasts of New Guinea and of Japan; and from the middle of the North Pacific Ocean (Station 246). *Umbellula* has, therefore, of all genera of Pennatulida the widest distribution.

Our knowledge of the *vertical* distribution of the Pennatulida has made great progress through the explorations of the Challenger. When I published my monograph I was justified in saying that the great majority of the Pennatulida were shallow-water

animals, living in the vicinity of the coasts, at a depth of 6 to 10 or 20 fathoms; but now the number living at great depths has so increased that it is nearly equal to that of the shallow-water forms.

If we compare the two groups, it is obvious that the great majority of the higher forms of the families PTEROEIDIDÆ, PENNATULIDÆ, VIRGULARIDÆ, and RENILLIDÆ live in shallow water. The only species going deeper than 100 fathoms, are—

	Fathoms.
Pennatula grandis, Ehrenb.,	150–200
P. phosphorea, var. *aculeata*, Köll.,	30–300
Dubenia abyssicola, Kor. and Dan.,	100–120
Pavonaria africana, Stud.,	360–
P. finmarchica, Sars,	240–300
Virgularia bromleyi, Köll.,	565–

Of the lower groups of the Pennatulida, only the Veretillidæ seem to live in shallow water (*V. cynomorium*, var. *astyla* was found by Studer, at the Cape de Verde Islands, in 115 fathoms). All the others are, with very few exceptions, deep-sea forms, as shown by the following list:—

	Fathoms.
FUNICULINIDÆ.	
Funiculina quadrangularis, Blainv.,	20–350
Halipteris christii, Kor. and Dan.,	200
STACHYPTILIDÆ.	
Stachyptilum macleari, Köll.,	129
ANTHOPTILIDÆ.	
Anthoptilum thomsoni, Köll.,	600
murrayi, Köll.,	1250
simplex, Köll.,	1900
KOPHOBELEMNONIDÆ.	
Kophobelemnon stelliferum, var. *durum*, Müll.,	40–300
stelliferum, Köll.,	458–690
ferrugineum, Köll.,	345
(sp.),	700
Bathyptilum carpenteri, Köll.,	650
UMBELLULIDÆ.	
Umbellula güntheri, Köll.,	1850
simplex, Köll.,	2050
leptocaulis, Köll.,	2440
durissima, Köll.,	565
huxleyi, Köll.,	565

	Fathoms.
Umbellula magniflora, Köll.,	1600
magniflora (?), Köll.,	1375
carpenteri, Köll.,	1950–1975
thomsoni, Köll.,	2125
lindahli, Köll.,	122–410
(sp. Studer),	360

PROTOCAULIDÆ.

Protocaulon molle, Köll.,	700
Cladiscus gracilis, Kor. and Dan.,	40

PROTOPTILIDÆ.

Protoptilum thomsoni, Köll.,	322
carpenteri, Köll.,	690
smitti, Köll.,	223
aberrans, Köll.,	1700
aberrans, var. Köll.,	1240
aberrans, var. Köll.,	1350
Lygomorpha sarsi, Kor. and Dan.,	80–100
Microptilum willemöesi, Köll.,	565
Leptoptilum gracile, Köll.,	700
Trichoptilum brunneum, Köll.,	129
Scleroptilum grandiflorum, Köll.,	2300
durissimum, Köll.,	565

It follows from all these facts, as I have already pointed out in my monograph (page 449), that the simpler forms of the Pennatulida, especially those with sessile polyps, inhabit great depths. The presence of their less complex representatives in deep water has also been shown in other invertebrate groups. These simpler forms are probably also the oldest, and may be regarded as the last remnants of an extinct primary creation. The Protoptilidæ and the Umbellulidæ are the principal representatives of these old forms, and of these two families especially the Challenger Expedition has discovered a large number of species with a wide distribution. This addition to our knowledge makes it possible to gain a better insight than formerly into the development of the whole group. On this point I may refer the reader to my often-quoted monograph, in which the phylogenetic development of the Pennatulida is treated on the 449th and following pages.

EXPLANATION OF THE PLATES.

Fig.
1. *Pennatula naresi,* Köll., from the ventral side.
2. The same from the dorsal side.
3. *Pennatula sulcata,* Köll., *a,* from the dorsal; *b,* from the ventral side.
4. A part of the dorsal side of *Pennatula sulcata* twice the natural size.
5. *Pennatula pearceyi,* Köll., twice the natural size.
6. *Pennatula murrayi,* Köll., from the dorsal side.
7. The same from the ventral side.
8. *Pennatula moseleyi,* Köll., from the dorsal side.
9. A part of *Pennatula moseleyi,* from the ventral side.
10. *Virgularia bromleyi,* Köll., fig. 1, natural size; fig. 2, from the ventral aspect fig. 3, from the sides,—four times the natural size.
11. *Virgularia gracillima,* Köll.
12. *Scytalium tentaculatum,* Köll., *d,* dorsal; *v,* ventral side.
13. A young leaf of *Scytalium tentaculatum* magnified; (*) the tentacles at the end of the not yet developed polyp-cells.
14. A smaller but developed leaf of *Scytalium sarsi.*
15. Undeveloped leaf of *Scytalium sarsi.*
16. *Anthoptilum thomsoni,* Köll., *v,* ventral side.
17. A part of the same from the side, the polyps cut to show the lateral zooids.
18. A tentacle of *Anthoptilum thomsoni.*
19. *Antnoptilum murrayi,* Köll.
20. Part of the same from the ventral side, three times the natural size.
21. The same from the dorsal side.
22. *Anthoptilum simplex,* Köll., *v,* ventral; *d,* dorsal side.
23. *Protocaulon molle,* Köll., three times the natural size.
24. *Stachyptilum macleari,* Köll., *A,* ventral; *B,* dorsal aspect.
25. A part of the dorsal side of the same, three times the natural size.
26. Calcareous corpuscles of the tentacles of *Stachyptilum.*
27. *Microptilum willemœsi,* Köll., *A,* natural size; *B,* three times the natural size.
28. *Leptoptilum gracile,* Köll., *A,* natural size; *B,* three times the natural size.

Fig.

29. *Scleroptilum grandiflorum*, Köll., *A*, natural size ; *B*, a part of the rachis three times the natural size.
30. *Protoptilum aberrans*, Köll., *A*, natural size ; *B*, three times the natural size ; 1, dorsal, 2, ventral side.
31. *Trichoptilum brunneum*, Köll., *A*, natural size ; *B*, part of the rachis three times the natural size.
32. *Umbellula durissima*, Köll., *A*, dorsal ; *B*, ventral side.
33. The same, upper part, three times the natural size.
34. *Umbellula güntheri*, Köll., *A*, ventral aspect of the whole fragment ; *a*, swelling of the stalk with zooids ; *B*, dorsal side of the upper part.
35. *Umbellula leptocaulis*, Köll., fragment from the ventral side.
36. *Umbellula simplex*, Köll., from the ventral side.
37. *Umbellula huxleyi*, Köll., *A*, natural size ; *B*, upper part three times the natural size.
38. *Umbellula carpenteri*, Köll., *A*, dorsal aspect ; *B*, ventral side of the upper part.
39. Three young forms of *Umbellula carpenteri*, Köll., *A* and *B* from the ventral side, *C* from the dorsal side.
40. *Umbellula carpenteri*, part of the stalk, about twelve times the natural size, to show the ramified tentacles (*t*) of the zooid. The shorter tentacles are in part broken.
41. *Umbellula magniflora*, Köll., upper part, natural size.
42. Part of the lower swelling of the stalk of *Umbellula magniflora*, from Station 146, to show the zooids, three times and a half the natural size.
43. *Kophobelemnon ferrugineum*, Köll., from the dorsal side.
44. *Kophobelemnon*, sp., from the side.
45. *Kophobelemnon burgeri*, Herkl., *A*, from the dorsal ; *B*, from the ventral side.
46. *Renilla mülleri*, M. Sch., part of frond ten times the natural size ; *p*, polyps retracted ; *q*, groups of zooids.

Fig. 1.

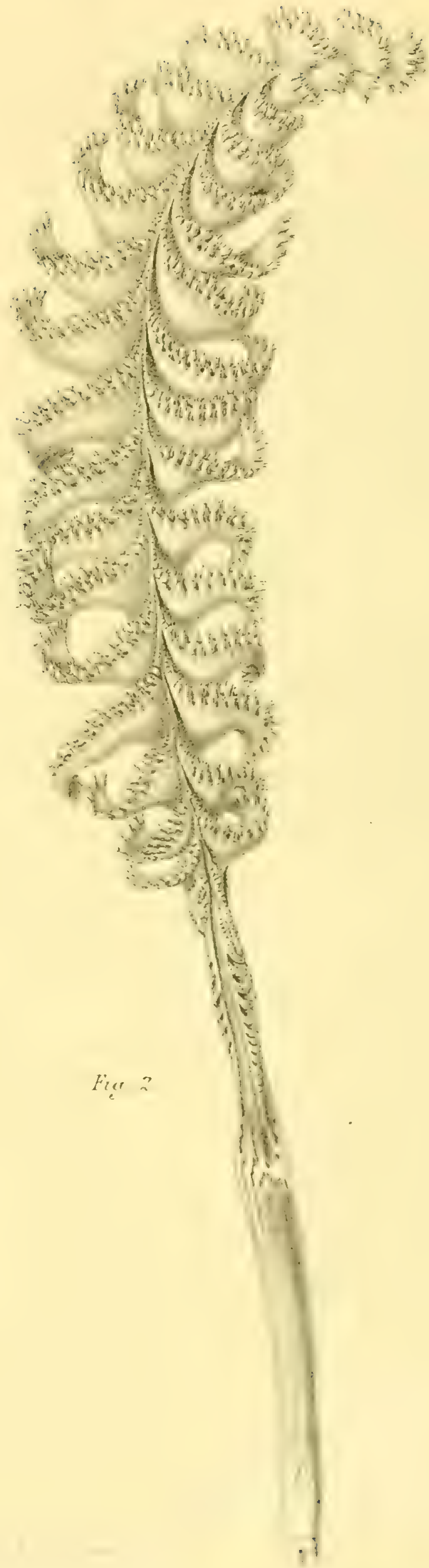


Fig. 2

A. Rabus, del.

PENNATULA

Fig. 4.

Fig. 3 a.

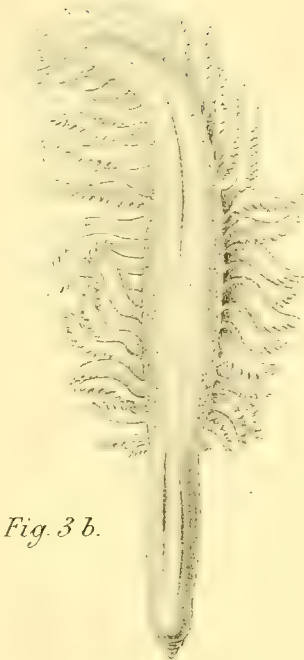


Fig. 3 b.

Fig. 9.

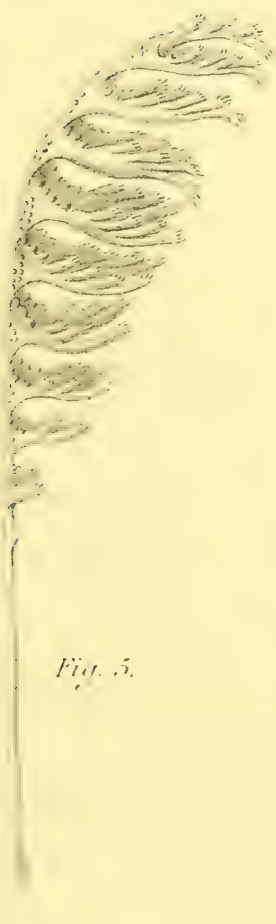


Fig. 5.

Fig. 6.

Fig. 7.

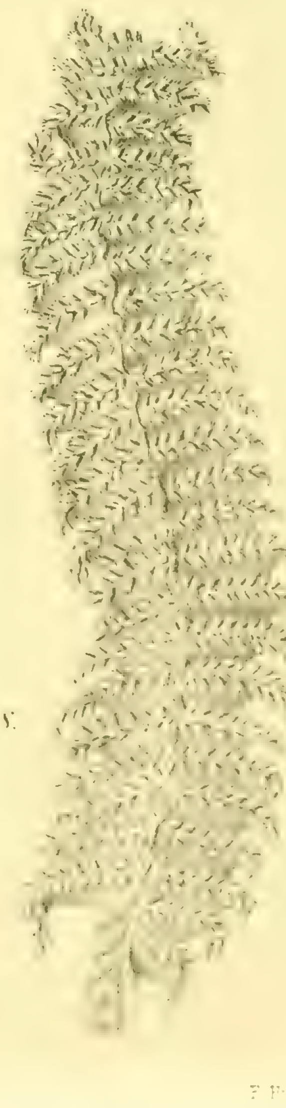


Fig. 8.

A. Rabus, del.

F. Huth, Lith^r Edin^r

PENNATULA

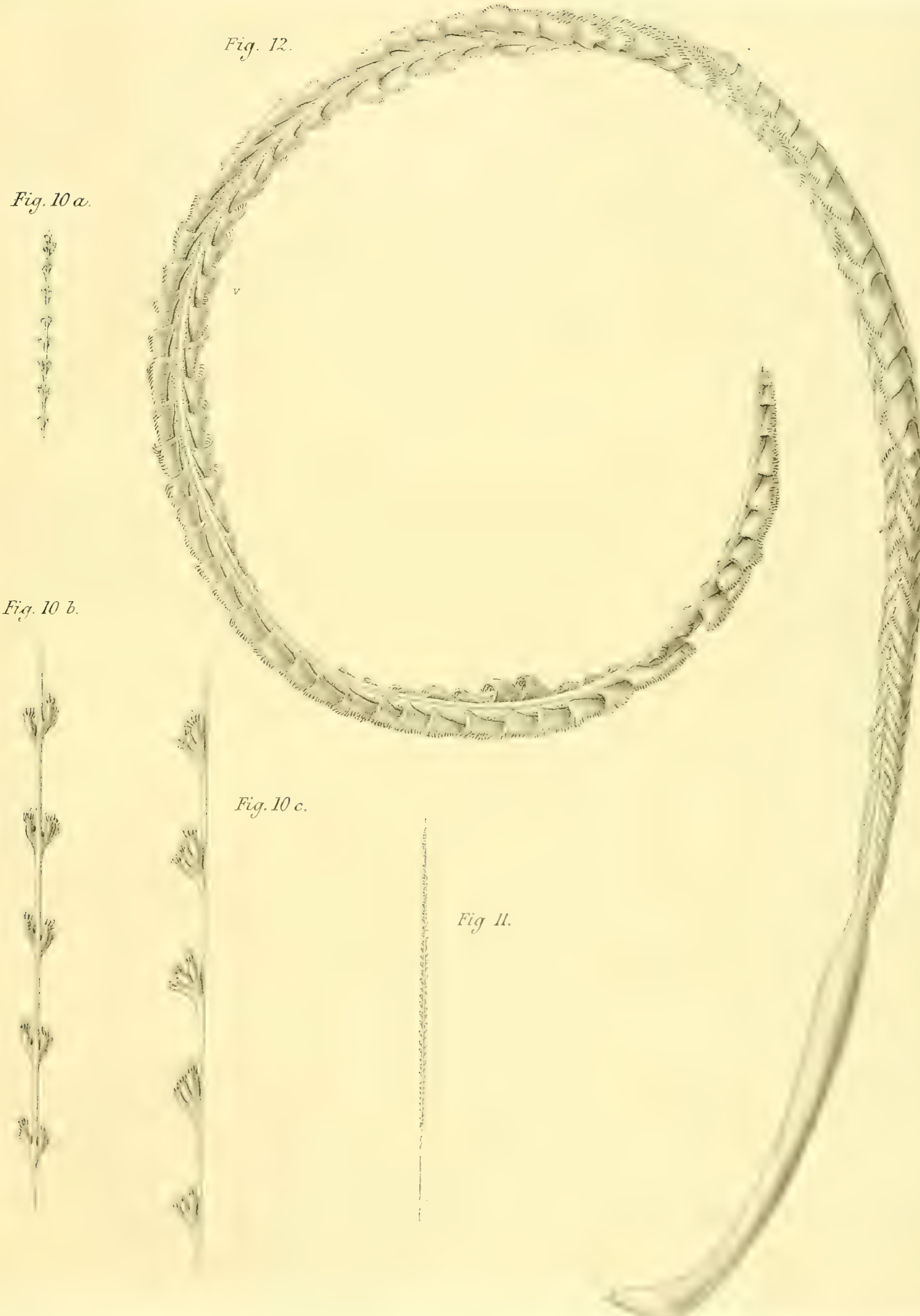


Fig. 12.

Fig. 10 a.

Fig. 10 b.

Fig. 10 c.

Fig. 11.

A. Rabus, del.

F. Huth, Lith^r Edin^r

VIRGULARIA. SCYTALIUM.

Fig. 16.

Fig. 17.

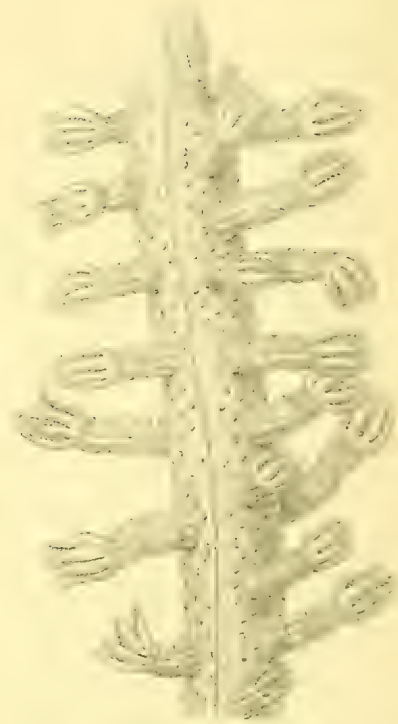
Fig. 18.

A. Rabus, del.

F. Huth, Lith^r Edin^r

ANTHOPTILUM.

Fig. 21.



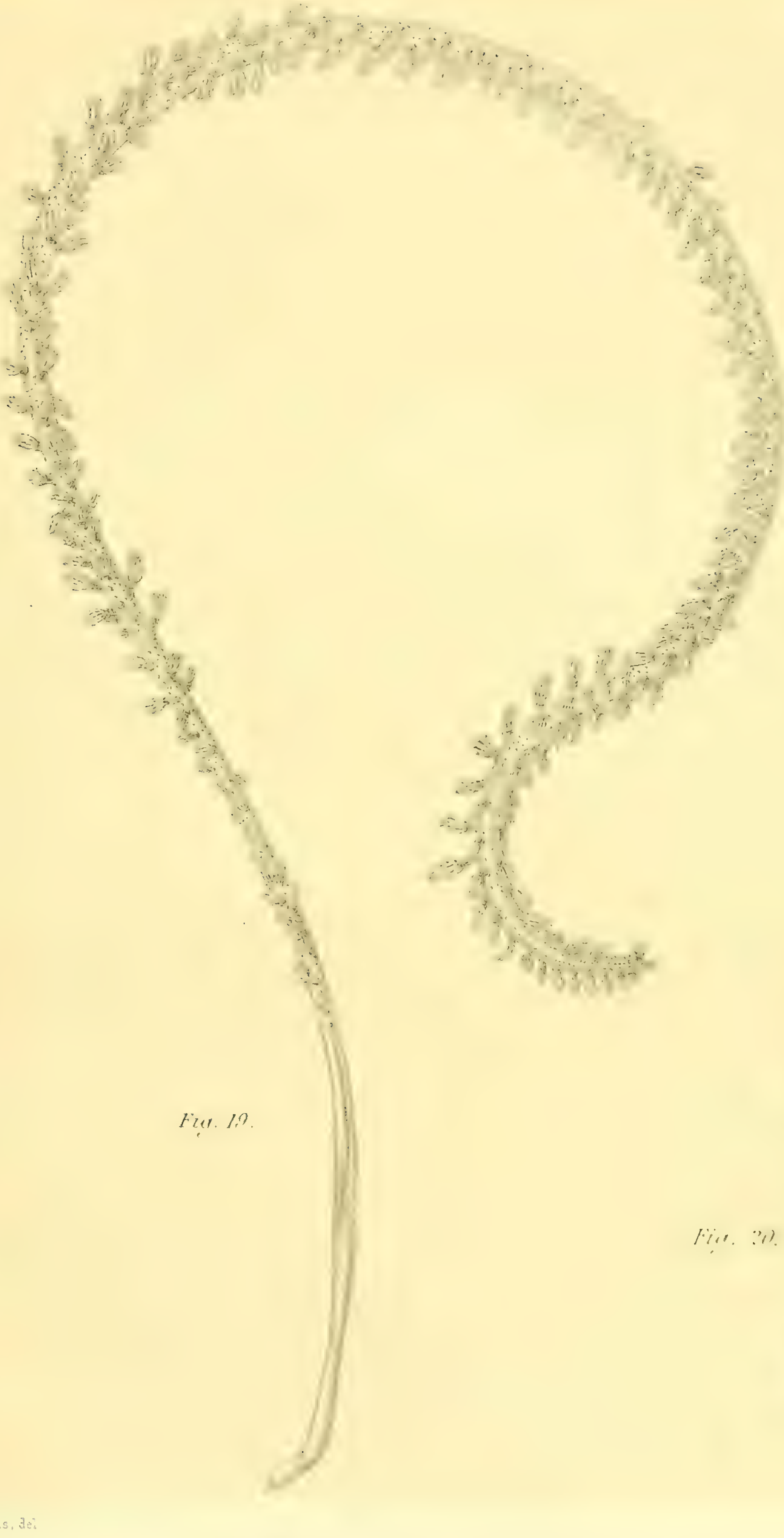


Fig. 19.

Fig. 20.

A. Rabus, del.

F. Huth, Lith.r Edin.r

ANTHOPTILUM

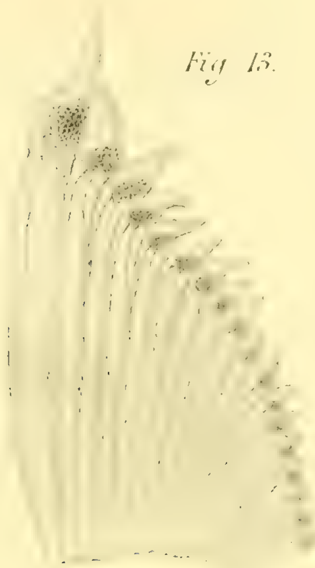


Fig. 13.

Fig. 22.

Fig. 14.

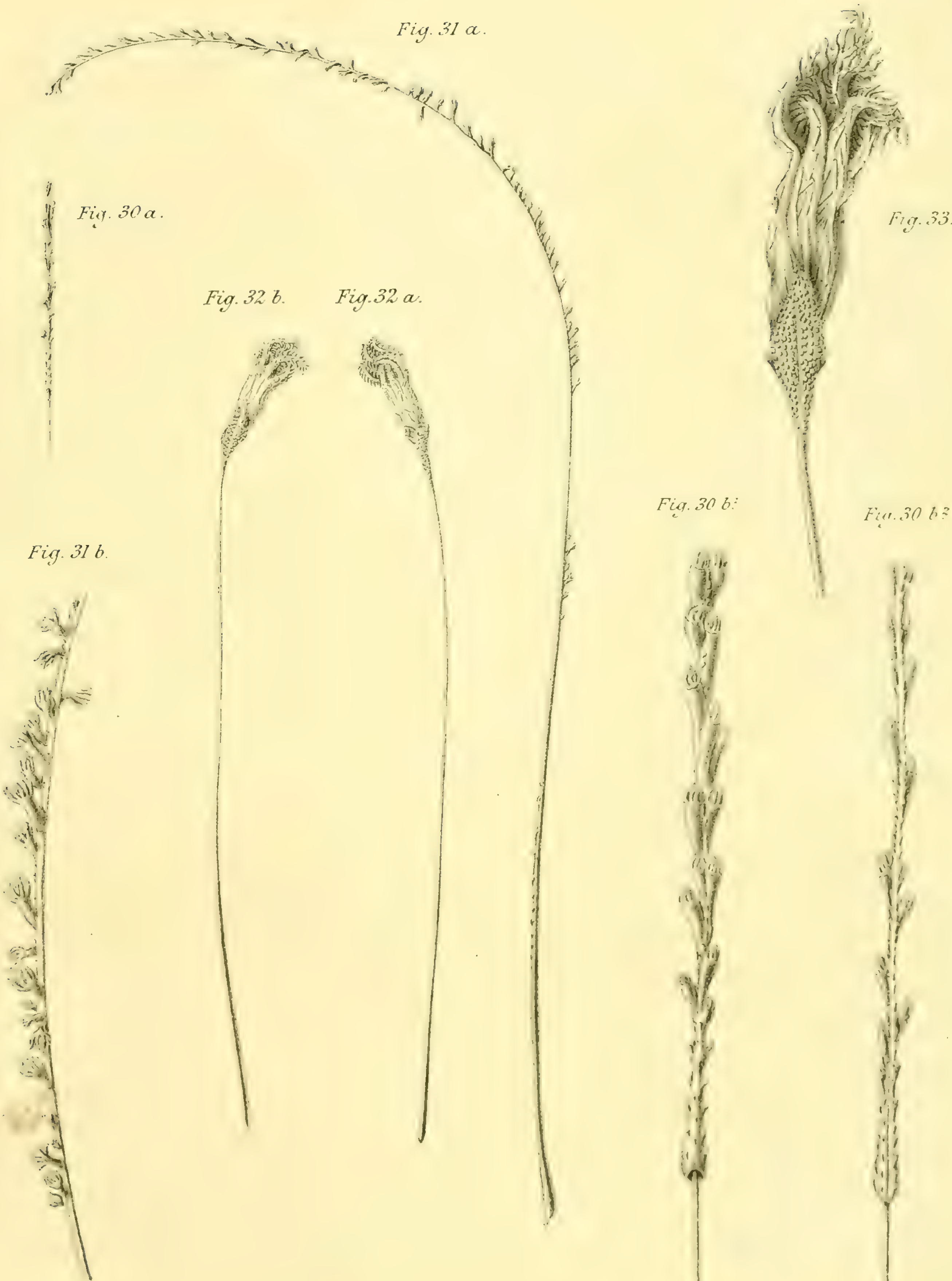
Fig. 15.

A. Rabus, del.

F. Huth, Lith.^{r} Edin.^{r}

SCYTALIUM. ANTHOPTILUM

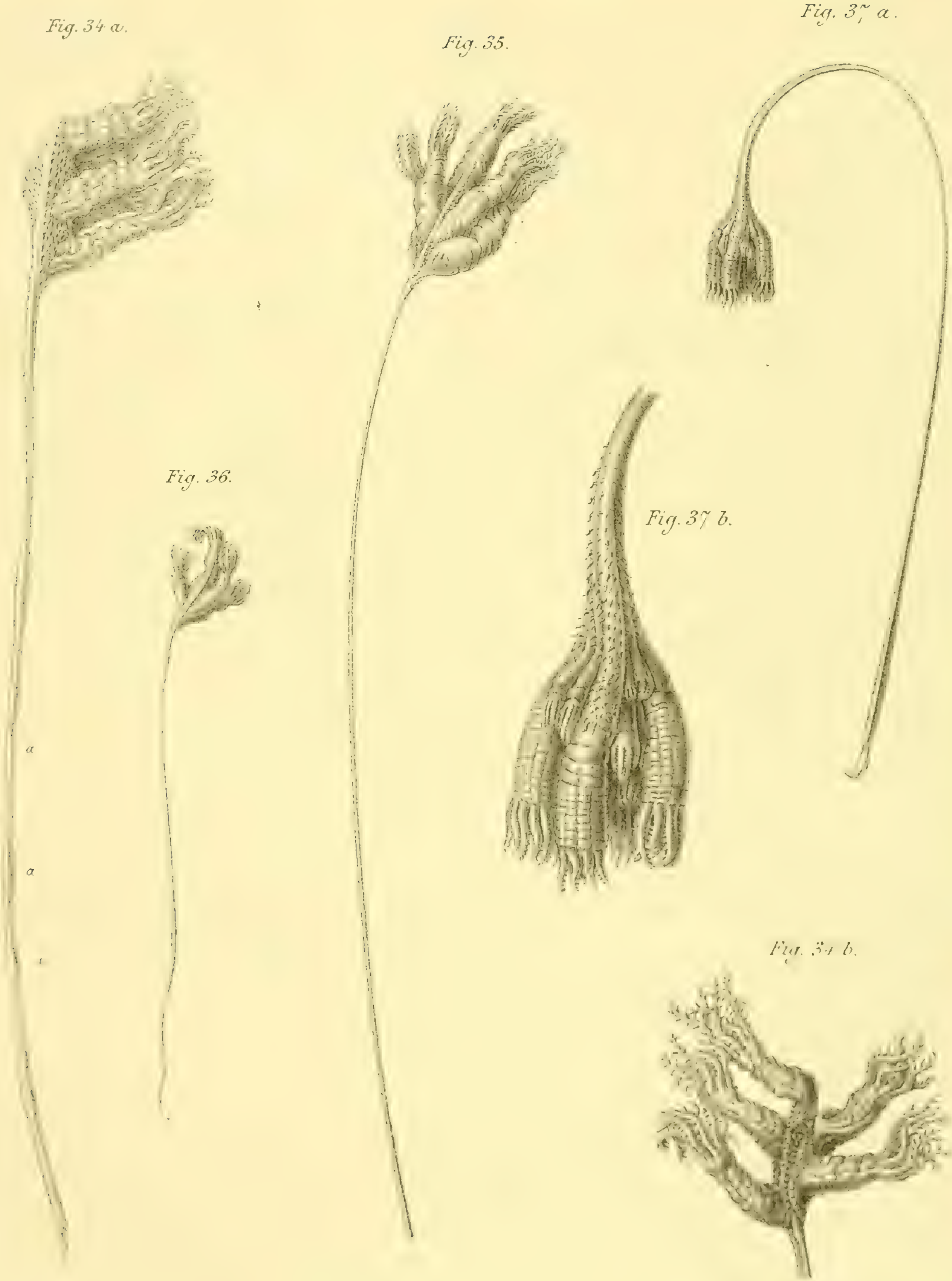
PROTOCAULON. STACHYPTILUM. MICROPTILUM.
LEPTOPTILUM. SCLEROPTILUM.



A. Rabus, del.

F. Huth, Lith.r Edin.r

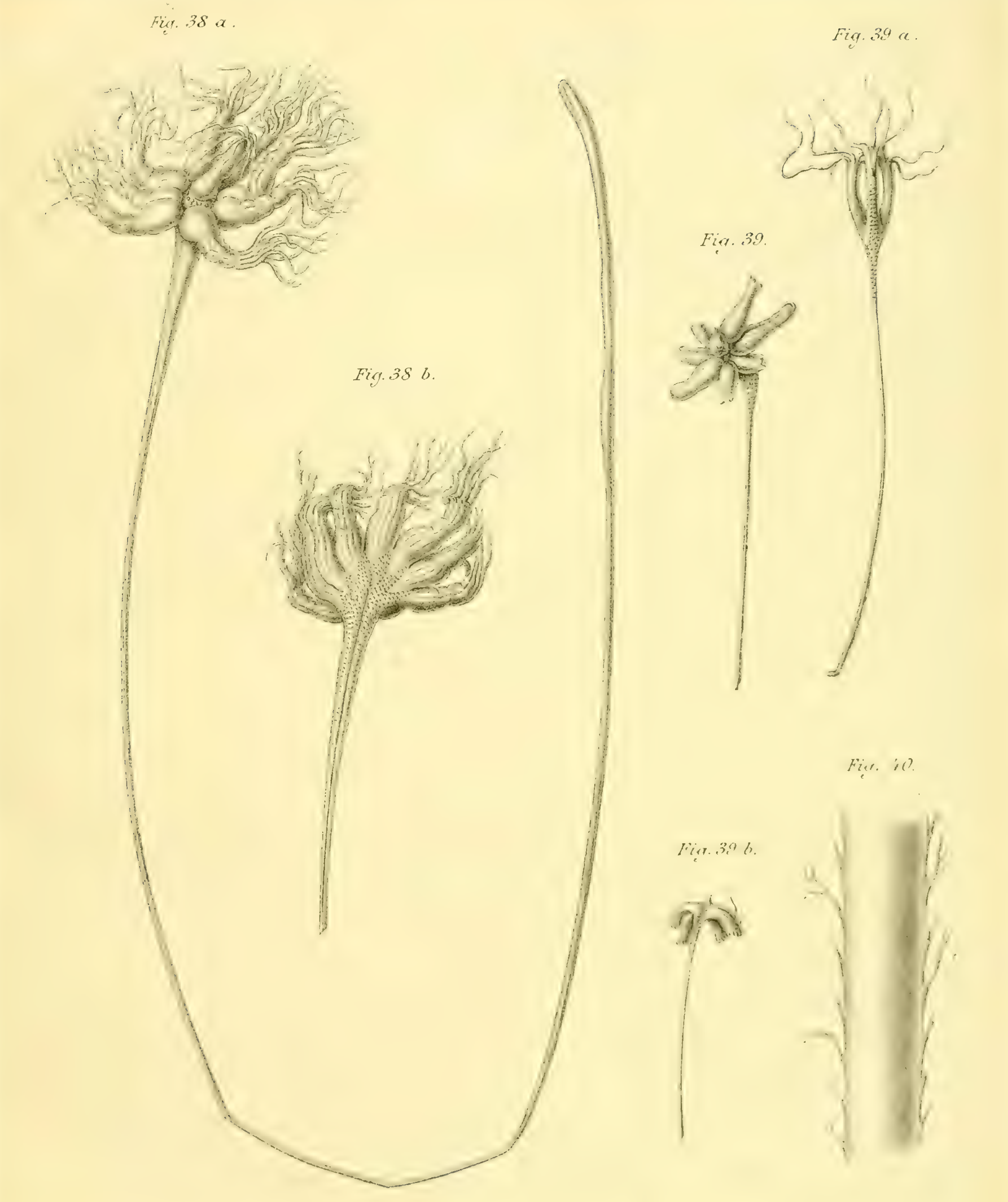
PROTOPTILUM. TRICHOPTILUM. UMBELLULA.



A. Rabus, del.

F. Huth, Lith' Edin'

UMBELLULA.



A. Rabus, del

F. Huth, Lith^r Edin^r

UMBELLULA.

Fig. 41.

Fig. 45.

Fig. 43.

Fig. 42.

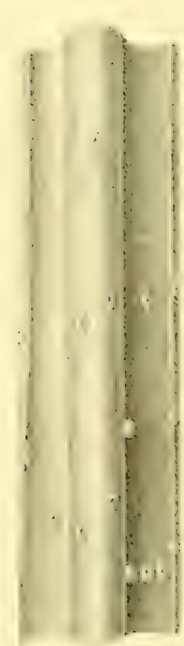


Fig. 46.

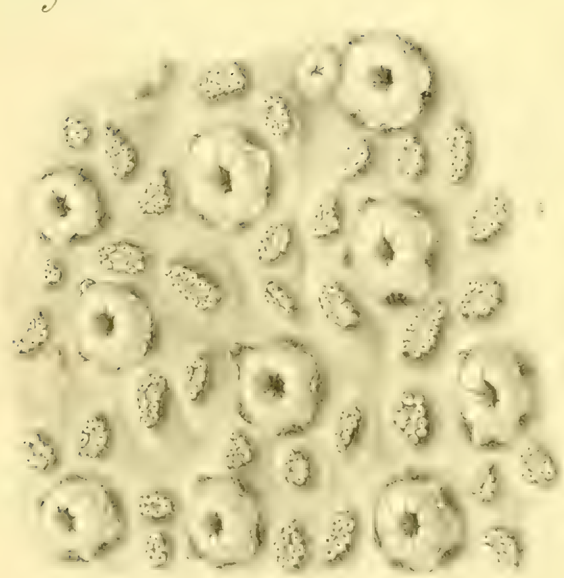


Fig. 44.

A. Rabus, del.

F. Huth, Lith.r Edin.r

UMBELLULA. KOPHOBELEMNON. RENILLA.

THE

VOYAGE OF H.M.S. CHALLENGER.

ZOOLOGY.

REPORT on the CIRRIPEDIA collected by H.M.S. Challenger during the years 1873–76. By Dr. P. P. C. HOEK, Member of the Royal Academy of Science of the Netherlands.

ANATOMICAL PART.

INTRODUCTION.

ONE of my principal reasons for wishing to investigate the Cirripedia dredged during the cruise of H.M.S. Challenger was the hope that I should be able by the aid of the deep-sea material to enlarge our knowledge of the morphology of the order. It was possible that among the forms from considerable depths there might be some which on account of their great size, or for other reasons, would be especially favourable for anatomical research, as was the case with some of the Pycnogonids from the abysses. It was possible also that among them a new form might occur, the investigation of which would cast light on details in the organisation which had not hitherto been sufficiently understood. In this respect, however, the study of the deep-sea material has somewhat disappointed my expectations; the new forms for the most part are represented by single specimens only, or are too small to be dissected advantageously. I have therefore been obliged to limit my researches entirely to such forms as were previously known and had served for the researches of former investigators. They belong to the genera *Lepas*, *Conchoderma*, and *Scalpellum* of the pedunculated Cirripedia, and to the genus *Balanus* of the sessile Cirripedia. What I have been able to work out does not form a connected whole, but may conveniently take the form of separate chapters in the morphology of the group.

I. THE COMPLEMENTAL MALES OF SCALPELLUM.

Since 1851, when Darwin issued the first volume of his Monograph on the Sub-class Cirripedia, nothing has been published on the so-called complemental males of *Scalpellum*, though the subject was far from exhausted by his treatment of it. The truth of this assertion in no way diminishes the respect which we feel to be due to the labours of the great master in this department of investigation as well as in so many others. For when we consider that the methods of microscopic research have been greatly improved in the thirty years which have since elapsed, and that the male of *Scalpellum vulgare*, which Darwin investigated, has a size of only 0·7 mm., we can only wonder at the thoroughness of the information which he has given, and at the soundness of the conclusions at which he arrived.

When dissecting *Scalpellum vulgare*, Leach, Darwin observed one or more very minute parasites on the margins of both scuta, close to the umbones. He dissected one or two specimens and at first concluded that they belonged to some new class or order amongst the Articulata. By repeated and more careful dissection he was able to make out the general appearance of the animal, the form of the thorax and abdomen, the generative system, the antennæ and the mode of its attachment; he found that the prehensile antennæ of the little parasite showed an absolute correspondence with the same organs of the hermaphrodite *Scalpellum vulgare*, and that it belonged exclusively to the male sex. From this knowledge, together with its fixed condition and its short existence, he thought himself justified in provisionally considering the little parasite as the complemental male of the Cirriped to which it was attached.

The results of Darwin's investigation of the complemental males of the other species of *Scalpellum* known to him are, shortly, the following:—The complemental male of *Scalpellum ornatum*, Gray, sp., shows a close general resemblance to that of *Scalpellum vulgare;* but as Darwin had only dried specimens of that species, his description is not so exhaustive; he found males of *Scalpellum rutilum*, Darwin, also, but in so extremely decayed a condition that they could not be examined. What Darwin considered to be the complemental male of *Scalpellum rostratum*, Darwin, is a little animal constructed like an ordinary Cirriped and furnished with a mouth, thorax, and cirri, enclosed in a capitulum (with a carina and a pair of scuta), and supported on a peduncle of moderate size. Specimens were found attached to the integument of the hermaphrodite in a central line between the labrum and the adductor scutorum muscle. The complemental male of *Scalpellum peronii*, Gray, sp., is a pedunculated Cirriped with a capitulum of six valves, firmly cemented to the integument of the hermaphrodite in a fold between the scuta, in the middle line a little below the adductor scutorum muscle. Finally, the complemental male of *Scalpellum villosum*, Leach, sp., is attached in the same position as that of *Scalpellum peronii;* it is also six-valved and it has a close general

resemblance to that of *Scalpellum peronii*. Whereas the parasites in the first three species (*Scalpellum vulgare, Scalpellum ornatum,* and *Scalpellum rutilum*) are in such an extraordinarily modified and embryonic condition, that they can hardly be compared with other Cirripeds, those of the other three (*Scalpellum peronii, Scalpellum rostratum,* and *Scalpellum villosum*) are pedunculated Cirripedia, remarkable for their smallness.

These are the facts which were known to Darwin; he then enters into a masterly discussion of the evidence that these parasites are really the males of the Cirripedia to which they are attached. Curious and novel as was the fact, his reasoning was so convincing that this theory has been generally accepted.

With respect to the occurrence and the structure of these complemental males, I believe I have been enabled to augment our knowledge not inconsiderably. Though the principal result of my investigations has been to convince me of the exactness of Darwin's theory, I think the question is important enough to justify me in giving all the information which I possess in the following pages.

I observed the complemental male in nineteen out of the forty-one new species of *Scalpellum* described in my Report.[1] I found them all in or about the same place, viz., at or near the occludent margin of the scutum at the interior side of this valve, a little above the adductor muscle. As a rule they are placed in a pouch formed by the mantle; very often, but not always, I found them on the left as well as on the right hand scutum. In five different species I took either from one or from both scuta two or more specimens, in the other species each, or one only, of the two scuta was furnished with a single male. In one species (*Scalpellum marginatum*) the male was seated at a considerable distance from the occludent margin of the scutum, and hence it happened that at first I did not find it out. In one species (*Scalpellum recurvirostrum*) the only male observed was still in the Cypris-larval or pupa stage; in three other species (*Scalpellum regium, Scalpellum eximium,* and *Scalpellum velutinum*) males in the pupa stage were attached along with full-grown males. The male of *Scalpellum brevecarinatum* could not be studied, being in a very unsatisfactory condition.

In eighteen out of the nineteen cases I was able to form an opinion as to the condition of the male when the testis was ripe, and the little creature therefore full-grown or nearly so. In five of these eighteen cases the condition can be said to correspond with that of the male of *Scalpellum vulgare*. In thirteen the males are still more degenerate. These five are *Scalpellum tritonis, Scalpellum intermedium, Scalpellum parallelogramma, Scalpellum elongatum,* and *Scalpellum triangulare*. I think they correspond with *Scalpellum vulgare* in as far as there are rudimentary valves visible in them. The thirteen remaining species all, no doubt, belong as regards the structure of their males

[1] Zool. Chall. Exp., part xxv. The small species represented by single specimens have not been investigated so thoroughly as would have been necessary to make out whether a male really occurred or not. I often found myself unable to do so without spoiling the specimen.

to one and the same division of the genus. I have been able to study the male of one of these (*Scalpellum regium*, Wyv. Thoms., Hoek) more in detail; in all essential respects the males of the other twelve agree with it.

The twenty-four species of *Scalpellum*, the males of which are known at present, may be classified with regard to the structure of these males in the following way.

A. Species, the males of which show a distinct capitulum and peduncle:—

Scalpellum peronii, Gray, sp.
Scalpellum rostratum, Darwin.
Scalpellum villosum, Leach, sp.

All these are shallow water species.

B. Species, the males of which do not show a division of the body into a capitulum and a peduncle, but yet are furnished with rudimentary valves:—

Scalpellum vulgare, Leach.
rutilum, Darwin.
ornatum, Gray, sp.
intermedium, Hoek.

Scalpellum parallelogramma, Hoek.
elongatum, Hoek.
tritonis, Hoek.
triangulare, Hoek.

Species occurring in depths varying between shallow water and 700 fathoms.

C. Species, the males of which do not show a division of the body into a capitulum and a peduncle, and are not furnished with rudimentary valves:—

Scalpellum marginatum, Hoek.
strömii, Sars.
compressum, Hoek.
nymphocola, Hoek.
velutinum, Hoek.
eximium, Hoek.

Scalpellum gigas, Hoek.
regium (Wyv. Thoms.), Hoek.
darwinii, Hoek.
tenue, Hoek.
dubium, Hoek.
flavum, Hoek.

Scalpellum pedunculatum, Hoek.

With the exception of three (*Scalpellum pedunculatum*, *Scalpellum strömii*, and *Scalpellum nymphocola*), these species occur in depths of upwards of 1000 fathoms. The depths at which *Scalpellum strömii* and *Scalpellum nymphocola* were collected are less considerable; these species, however, belong to the arctic fauna, which, as is well known, shows numerous instances of deep-sea animals occurring in rather shallow water. *Scalpellum pedunculatum* was taken from a depth of 150 fathoms only.

a. Description and Comparison of Cypris-Larvæ.

At first I experienced great difficulties in identifying the parts of the body of the complemental male; however, I believe I have solved the problem by comparing the full-grown male with a younger stage of its development, and the latter with the corresponding stage of an ordinary species of *Lepas*. The occurrence of a Cypris-larva between the two complemental males at the ordinary place enabled me to make this comparison; from its structure as well as from the place whence it was taken there can be no doubt, I believe, that this latter creature was destined to develop (retrogressively of course) into a complemental male.

The species of *Lepas*, the Cypris-larvæ of which have served me for comparison, was the *Lepas australis*, Darwin. It is not only very characteristic on account of its great size, but it is also the best known Cypris-larva, as it served first for the investigations of Darwin, and again some years ago for the studies of Claus. The latter has given a very good figure of the internal structure of this larva as seen in a sagittal section. My figs. 1 and 2 on Pl. II. very closely correspond to that of Claus. My fig. 1 was drawn from a preparation made by dividing the body of the Cypris-larva of *Lepas australis* into two nearly equal halves by means of a sagittal section. The rounded spot (*A M*) is the adductor muscle of the two valves of the Cypris-larva; the straight line at the under side of the valve represents the ventral side, the convex one the dorsal side; the extremity on the left of my figure the frontal (cephalic), the one facing it the hinder (abdominal) extremity of the body; from the way in which the spines of the legs are stretched out at the ventral side it is clear that there is a slit-like opening between the adductor muscle and the hinder extremity of the body. In fig. 2 of Pl. I., representing a longitudinal section parallel to and at a little distance from the ventral margin, this orifice is also distinct. This is the only place where the interior of the sack or mantle (as Darwin calls it) is in open communication with the surrounding water.

The body of the future *Lepas* is enclosed within the sack and has also a wall of its own; on one side (the right hand side of the figure) this wall is very distinct, and it passes over near the middle of the dorsal margin into a transverse invagination which almost reaches up to the ventral side. It is by this invagination that the division of the body into a capitulum and a peduncle is brought about; what in fig. 1 of Pl. II. is placed on the right hand side of the invagination (*Inv.*) is the capitulum, what is placed on the left hand side the peduncle. As the invagination of the dorsal wall does not reach as far as the ventral side, a direct communication remains between the capitulum and the peduncle. Through this commissure, which is very narrow in the full-grown animal, pass the oviducts and the nerves destined for the peduncle.

On the ventral side an invagination is seen at a distance of about one fourth of the total length from the peduncular extremity; at the bottom of this invagination, when

studied in a sagittal section as figured, the compound eyes—which, according to Darwin, are attached to the basal joints of the antennæ—are visible.

The structure of the interior of the body can easily be made out by the aid of the figure. *M.* is the mouth; it is surrounded by darkly pigmented parts, the exact shape of which is not very distinct; the mouth gives entrance to the œsophagus (*Œ*); the latter has a horizontal direction, is furnished with a pair of cœca (*C*), and leads into a very capacious stomach (*S*), from which a narrow intestine (*Int.*) is seen to start. Œsophagus, cœca, stomach, and intestine are all very darkly pigmented. The six pairs of cirri and the caudal appendages present nothing particularly interesting; the different cirri have only to shed their skin to change into the cirri of the *Lepas*; the caudal appendages will have to undergo a very marked retrogressive metamorphosis to change into the rudimentary, uniarticulate, and smooth appendages of the full-grown *Lepas australis.* The nervous system is already quite distinctly visible; it consists of the supraœsophageal ganglion (*GS*), and the six thoracic ganglia (*G I.–G VI.*). The first is situated very close to the cœca of the œsophagus and has a simple eye (*e*), represented by a small triangular spot of pigment attached to it (fig. 2, *e*). The chain of thoracic ganglia is on the right hand side of the stomach, between this organ and the ventral wall of what is properly the body. The ganglia are not yet separated by commissures, but are placed close to one another; the first has an oval shape and is much larger than the following ones The ganglionic cells which cover the surface of the different ganglia are extremely small.

In the peduncular part of the body nearly all the room is filled up by a mass of connective tissue with very large meshes; between this mass of reticular connective tissue and the layer of cells which represents the mantle a double layer of muscular fibres may be discerned. The fibres of the two layers are at right angles to each other, and both layers run parallel to the surface of the body and the valves of the Cypris; in the figure, one of these layers is represented by the lines running parallel to each other, and also to the curved frontal line of the larva. This layer is composed of rather broad fibres (each fibre has an oval, not very elongate nuclei) and a breadth of 0·012 mm., which will develop into the layer of longitudinal muscles of the peduncle of the *Lepas.* The other layer is situated between the former and the mantle, and shows much narrower fibres, with very narrow and elongate nuclei (each fibre has a breadth of only 0·003 mm.); this latter layer forms the circular muscular layer of the peduncle in the full-grown *Lepas.* The cells which constitute the mantle are relatively small and are furnished with large nuclei (0·01 mm.); at different places they are richly pigmented.

Between the fibres and nuclei of the connective tissue numerous fatty bodies are visible which are more like vesicles than grains; they have an elongate shape, are pointed at both extremities, and belong to what still remains of the yolk.

The cell-masses which Claus[1] describes as the cement-glands were very strongly

[1] Claus, C., Die genealogische Grundlage, &c., Wien, 1876, p. 87.

developed in the larvæ of *Lepas australis* which I studied. Claus says that these glands consist of groups of cells which have either still the form of a sinuous string ("eines gewundenen Stranges") or which lie scattered by the side of one another; the latter is the case in *Lepas australis.* Claus has not observed the communication of these glands with the cement-duct which he figures; at least in his figure they are at a very considerable distance from one another. I have not been more fortunate; I even failed to observe the cement-duct. The different cells (Pl. II. fig. 5) do not show much resemblance to the cement-glands of the full-grown animal; yet I think that Claus' supposition as to the nature of these elements is right. As regards the place they occupy in the Cypris-larva, it quite corresponds to the place they occupy in the full-grown animal, viz., in the most posterior (when the animal changes its position, the most superior) part of the peduncle. The Cypris-larva which furnished the drawing fig. 2 is a little older than the one figured in fig. 1. In the former the cement-cells are much more separated from one another than in the latter; moreover, their nuclei are much more easily distinguishable, and many of them are not so richly furnished with fatty granules as was the case in the younger condition. Very delicate and flat fibres in the later Cypris-stage are visible between the cement-cells; probably they represent the canals figured by Claus and considered by him as branches of the cement-ducts.

A pair of club-shaped bodies is situated near the ventral wall of the animal, the thickest part of which is directed towards the front of the Cypris and the narrower part of which can be traced as far as under the cœca of the œsophagus of this larva. These are described by Claus as the ovarium (figs. 1 and 2, *Od*). I observed these bodies also, and I think it very probable that they represent the female genital apparatus; they are especially distinct in the longitudinal section of the body shown in fig. 2. In this figure the valves of the Cypris are not represented; the clear margin round the body represents the chitinous wall of the future *Lepas;* the cells of the mantle serve as a matrix for its formation.

When we look now at the figure of the Cypris-larva of *Scalpellum regium* which is destined to develop into a complemental male, we observe great analogy as well as considerable difference. Pl. II. fig. 3 represents a larva which has probably attached itself lately, and which therefore is exactly in the same stage as the larva of *Lepas australis* which I have just described. It is somewhat different from the latter in general outline, being more elongate and not so high. At the hinder extremity the Cypris of *Lepas australis* is obliquely truncated and bluntly pointed, and that of the male of *Scalpellum* almost entirely transversely truncated. Like the former it is enclosed within a shell consisting of two valves of a very brittle constitution. The antennæ (*An*) are stretched forward out of the ventral slit between the two valves; they have in all essential respects the same structure as those of the full-grown complemental male which will be described further on. At their base in the interior of the body of the larva a cellular

body is visible which, I think, must necessarily represent the cement-gland. However, neither the place it occupies nor its structure shows any resemblance to the same glands—or what we must consider as such—in the Cypris of *Lepas australis.* Nor have these glands in the male of *Scalpellum regium* great conformity with those organs in the younger Cypris-stage of another species of *Scalpellum* (*Scalpellum triangulare*) which I figure in Pl. II. fig. 4. In this stage the antennæ (*An*) are still totally hidden within the valves, and the cement-glands (*C. gl*) form very large cellular masses situated on both sides of the thoracic part of the body between it and the valves. I think it is in this stage that the Cypris-larva leaves the mantle cavity of the mother.

What we called the mantle in the Cypris of *Lepas australis* takes in the male Cypris of *Scalpellum regium* the form of a bag closed on all sides, with only a very small opening at the hinder extremity. This opening no doubt corresponds to the slit-like opening at the ventral side of the Cypris of *Lepas.* It also serves the same purpose. We see the very delicate and slender spines placed at the extremity of the legs come forth from this opening. For want of material I have not been able to study in detail the structure of the mantle, nor its musculature. I can only say that the mantle is composed of flat and pale rounded cells of 0·01 mm. in diameter, with a small clear nucleus, and that these cells are placed at a little distance from each other; that the muscular fibres form a single layer only, and are built up of elongate oval cells placed in longitudinal rows and each furnished with a distinct nucleus (Pl. I. fig. 7). Besides the body the interior of the mantle contains a mass of connective tissue with little grains and small fatty corpuscles scattered irregularly throughout its meshes. With regard to the body it is not difficult to observe the mouth (Pl. II. fig. 3, *M*), the œsophagus (*Œ*), and the stomach (*St*); the nervous system consisting of a supraœsophageal ganglion (*G S*) and a single, rather large thoracic ganglion (*G T*); six pairs of very slender cirri with delicate spines at their extremities; a pair of long and well developed caudal appendages (*C A*). A dark-coloured mass consisting for the most part of yolk-fragments makes up a great deal of the rest of the true body of the embryo *Scalpellum.*

As for details, I can only say that the parts which surround the mouth are not very distinct, and that the very long œsophagus leads into a blind pouch of an oval shape, and that this pouch represents the stomach. The two branches of each cirrus are indistinctly divided into four segments; the shape of each segment is cylindrical, with the exception of the last joint, which is conical and slopes into the very long spines placed at the extremity. The first two pairs of cirri are somewhat different from the following pairs, in as far as in the first two the lower two segments are the only ones which are filled up with a mass of cellular structure; so, when the cirri have shed the exuviæ which now cover them, the cirri of the first two pairs undergo a considerable loss of length. The very long caudal appendages in this stage are also only represented by the chitinous skin. After the last casting of skin they will no doubt have disappeared.

The supraœsophageal ganglion is well-developed; in one of the specimens two nerves were indistinctly visible starting from the ganglion and directed towards the antennæ; if my observation be correct there can be little doubt that these are the antennal nerves. I have not observed the commissures which unite the supraœsophageal ganglion with the thoracic ganglion; the latter is large and oval, and probably only represents the first larger ganglion of the thoracic chain of *Lepas.* Neither the small eye near the supraœsophageal ganglion nor the large compound eyes at the base of the antennæ are present; the pigment which is so richly distributed over all the organs and parts of *Lepas australis* is totally wanting in the male Cypris of *Scalpellum.* This no doubt finds its explanation in the circumstances under which the little animal is destined to live.

Of great importance is the fact that the dorsal invagination, which as we have seen causes the division of the body of *Lepas* into a capitulum and a peduncle, is totally lost in the metamorphosis of the Cypris of the male of *Scalpellum;* hence there is no trace of this division to be observed in the full-grown males. This want of a peduncle together with the smallness of the orifice of the mantle and the total absence of valves, form the most characteristic features of the male in question.

The metamorphosis of the Cypris-larva, in its latest stage (as figured), into the full-grown male is now I think easy to understand. In this respect at least it quite corresponds to the metamorphosis of *Lepas.* The difference between the latest stage of the Cypris of *Lepas australis* and the young Cirriped of that species is not greater, nor less either, I think, than that between the attached Cypris of *Scalpellum regium* and the young male; to say that the complemental male of *Scalpellum* is in its Cypris stage or thereabouts, is not in accordance with the facts.

The valves of the Cypris are first of all shed. The cells of the mantle or sack soon develop a distinct membrane of chitin at their surface, which no doubt is as efficient a protection as the shell was, but which contains no carbonate of lime and therefore is not so brittle. When the wall of the male is quite intact, its impenetrability makes it absolutely unfit for transference from absolute alcohol into oil of cloves; the alcohol leaves the little body faster than the oil enters it, whence the body wall becomes shrivelled. As the internal structure is best studied in a specimen placed in oil of cloves, and as for its investigation by transverse sections the passing through oil of cloves was also necessary, I found it very useful, when the specimens were quite sound, to make a little opening in the wall before transferring them into the oil. For the rest, this internal structure is very simple. The antennæ and the very delicate thorax with the legs are the only parts which show that the little body belongs to an articulate animal; the whole interior of the body is filled with a mass of connective tissue with very wide meshes, serving to keep the different organs in their places.

b. Anatomy of the Male of *Scalpellum regium.*

I will now proceed to give an anatomical description of the complemental male of *Scalpellum regium* (Wyv. Thoms.), Hoek. I choose this species because it is represented by numerous specimens, and also because it is one of the largest species in the Challenger Collection.

Form and dimensions.—The complemental male of *Scalpellum regium* has an elongated oval shape. Its length varies from 1·6 to 2·4 mm., its breadth is 0·63 to 0·71 mm. The difference in length corresponds to differences in some of the internal parts, especially of the testis. Whether it is occasioned by the growth of this organ I cannot say. The third dimension, the thickness, is nearly equal to the breadth. We may call the extremities of the longer axis the poles of the body, and I propose to call one the peduncular, the other the capitular pole (Pl. I. fig. 1).

The Antennæ.—The only appendages externally visible are the small antennæ, situated close to the extremity of the body corresponding to the peduncle of other Cirripedia; they are seated at a little distance from the extremity, on that side of the body which represents the ventral surface. They have two segments; one cylindrical, and about twice as long as the other, which is flat and triangular. What Darwin calls the third and ultimate segment of the antennæ is very distinct in the case of this little creature (Pl. I. fig. 3). It is articulated to the upper surface of the disk and directed rectangularly outwards. Whereas the main segments of the antennæ are not furnished with spines, this latter segment bears five spines at the end, and three very slender ones at a notch a little beneath the extremity of this segment.

With the aid of these antennæ the little creatures are attached to the inner surface of the scutum of the hemaphrodite or female. The triangular terminal segment of the antennæ, in all the cases I observed, surrounded the extremity of a transparent mass, which I think can safely be considered as the product of the cement-glands which are in relation with the antennæ. It is by means of this cement that the attachment of the triangular disk takes place. In the case of *Scalpellum regium* the males are attached a little above the adductor muscle, and as a rule, three of them are implanted so closely together as to touch each other. What I think very peculiar is, that in three different cases observed by me, two of the three males attached to the scutum were much further developed than the third; the first contained a fully developed testis and a well-filled vesicula seminalis, the third was still in the condition of a Cypris-larva (Pl. II. fig. 3), probably only lately attached to undergo its final metamorphosis.

The wall of the body is a chitinous skin which is comparatively thin and delicate; when a transverse section of the body is made, the chitinogenous epithelium beneath the

chitinous outer wall is easily observed. The external surface of the body-wall is clothed with microscopic spines, having a length of about 0·0235 mm., and placed in transverse rows (not quite so regularly as shown in fig. 1 of Pl. I.). As a rule, these spines are narrow and pointed at the extremity which is attached to the wall of the body and broadest at the other extremity. Here the free margin is deeply toothed, which gives the spines a certain resemblance to the scales of the Lepidoptera. In other places the incisions of the spines are so deep as to divide the scale into two or three narrow spines. A small circular space at the peduncular pole is left free from spines, and at the other extremity the terminal part is so completely covered with minute particles of mud and sand, that it is impossible to distinguish the little spines there. This latter part of the body is the only one which is visible when the little male is in its ordinary place, viz., between the mantle or "sack" (as Darwin calls it) and the scutum of the hermaphrodite. A small rounded part at the capitular extremity of the body is covered by a chitinous membrane of greater thinness. The nuclei of the chitinogenous epithelium are placed here much more closely and are more easily visible owing to the thinness of the chitinous wall. A narrow slit-like opening (fig. 1, *o*) divides this little circular space; it corresponds with the orifice of the capitulum of the pedunculated Cirripedia. It is not easy to distinguish the edges of this slit-like opening, owing, as Darwin suggested for the same orifice of *Scalpellum vulgare*, to their extreme thinness.

The chitinogenous membrane which is found beneath the chitinous outer wall shows the ordinary structure of very flat cells with indistinct limits and with rather distant but conspicuous nuclei. These nuclei are very close to one another at the small circular part at the capitular extremity (Pl. III. figs. 2 and 3). The slit which indistinctly divides this part gives entrance to a cavity which contains the thoracic part of the little male. This cavity is not lined by an epithelium; it is only surrounded by a somewhat more solid layer of the same connective tissue, which fills up the whole interior of the body of the male. This cavity is seen in transverse section in Pl. III. fig. 4. In all the specimens of this species which I investigated the thoracic part was always retracted high up into the interior of the body, so that even the very long spines at the end of the slender limbs never reached the slit-like orifice at the capitular pole. In the males of some of the other species (*Scalpellum intermedium*, *Scalpellum tritonis*) the spines at the end of the thoracic limbs extend beyond this orifice. This was often also the case in the males of *Scalpellum vulgare* as observed by Darwin, which always showed the whole thorax forced outwards through the orifice, a circumstance which perhaps was owing, according to Darwin, to the action of the spirits of wine and consequent endosmose.

Muscles of the body-wall.—Under the cells of the hypodermis a well-developed layer of muscular fibres is everywhere present; these muscular fibres are indistinctly transversely striated; in some of my preparations however the transverse striation is some-

what more distinct. Perhaps the indistinctly striated condition of the fibres is the consequence of their being nearly functionless and rudimentary.[1]

From their position close to the body-wall one feels inclined to compare these muscles together with the outer wall of the body with the "Hautmuskelschlauch" of worms, as the Germans call it. The muscular fibres form a single layer only; they have an irregular oblique direction, which in some parts approaches to a transverse, in other parts to a longitudinal position; their course is imperfectly parallel. Their structure is very simple and can be best studied in Canada balsam preparations; when seen in oil of cloves their transverse striation is so indistinct as to be hardly visible. It is from such a preparation that the fig. 6, Pl. IV. has been made. When making a preparation of them by means of needles they present themselves like flat bundles of delicate fibrillæ, each bundle having a breadth of about 0·01 mm.; they sometimes show a clear wall as a kind of sheath and are furnished with nuclei at intervals; the latter are elongate and—as appears on a transverse section of the muscle—cylindrical; they have a length of about 0·02 mm. and a transverse diameter of about 0·005. In a transverse section of the wall of the body, as in all the figures of Pl. III., the nuclei of the matrix are seen between the chitinous outer wall and the transverse sections of the muscles. In these sections the latter show a very curious structure (Pl. IV. fig. 5); whereas that side of the muscle-fibre which is directed towards the anterior of the animal is smooth and arched and shows the sheath in the form of a distinct margin; that side of the same fibre which is directed towards the exterior is deeply toothed; here the fibrillæ which compose the fibre seem to part in different ways. As I could observe this phenomenon only in very thin sections, there can be no doubt that this structure does not agree with the natural condition of the fibre. The nucleus of the muscle-fibre is sometimes placed near the outer wall, sometimes almost in the centre of the fibre. As to the development of the muscle-fibre, when comparing it with the condition of the muscular fibre in the Cypris-larva, we may suppose that the oval contractile cells which compose the larval fibre grow out into long fibres, the pointed extremities of which are no longer placed in a longitudinal row but have been pushed along each other.

The connective tissue is composed of fibres, but also of extremely delicate and finely granulated membranous plates which form the partitions between the large meshes. Its nuclei are round and flat and have a diameter of 0·008 mm. The fibres are more robust where they form the wall of the cavity in which the thorax is situated; we find also stronger fibres where they run in a straight direction from the organs to the wall of the little animal.

I have not observed a true body-cavity in these little males, and before I had studied the bodies of other Cirripedia by means of transverse sections, I was much

[1] Leydig (Zum feineren Bau der Arthropoden, *Arch. für Anat. und Physiol.*, 1855, p. 394), says that the muscle-fibres of young individuals of *Coccus hesperidum* are distinctly transversely striated, those of full-grown individuals which almost lost the function of locomotion are totally rudimentary (and smooth ?).

puzzled by this fact. A part of the body of this male corresponds to the peduncle of the pedunculated Cirripedia, and as this is also filled up with connective tissue—with the exception of a rather narrow tubular cavity towards the rostral side—I at first endeavoured to homologize the connective tissue of the male with that of the peduncle. Extending my researches also over the body of the hermaphrodite or female *Scalpellum*, over *Lepas* and other genera of Cirripedia, I found that the occurrence of a well-developed mass of connective tissue between the different organs within the body is the rule in all the Cirripedia. In the interesting essay on the cœlom-theory by the brothers Hertwig[1] we read that all the Arthropoda possess a very capacious body-cavity, and that in the full-grown animal the intestinal tract passes freely through this cavity, a dorsal mesentery uniting the intestine to the wall of the body being observed only in a younger stage of the development. Whether the plurality of typical forms of Arthropoda have been sufficiently investigated so as to allow of this conclusion to be drawn, I will not decide. Doubtless, however, the Cirripedia have a very rudimentary body-cavity, and a well-developed mass of connective tissue nearly fills up all the space left open between the wall of the body and the internal organs. So the complemental males in this respect also correspond in structure to the female and hermaphrodite animals.

The internal organs consist of the well-developed genital apparatus, the nervous system, the cement-glands, and the totally rudimentary and evidently functionless œsophagus and stomach.

Fig. 1 of Pl. I. shows these parts in their normal position; fig. 2 represents part of these organs more strongly magnified. Testis (*t*), vesicula seminalis (*vs*), and vas deferens (*vd*), can easily be made out in all the specimens. Neither do the other organs (the nervous system, and the œsophagus with the stomach), present any further difficulties after comparison with the structure of the Cypris-larva (Pl. II. fig. 3).

Digestive tract.—The œsophagus and the stomach have nearly preserved their original condition; the mouth has grown totally functionless; its place is indicated by the presence of a group of cells (Pl. I. fig. 2 *m*), which are placed in the connective tissue bordering the cavity in which the thorax is situated. The œsophagus is a narrow tube which imperceptibly widens and passes over into the stomach. The latter is a pyriform pouch closed on all sides, having a rudimentary intestine at the extremity opposite to the cardia. It has a double wall, as can be best studied in the transverse sections (Pl. III. figs. 6 and 7). Probably the internal wall represents a chitinous cuticle which has been shed, but which could not be removed, the mouth being closed. Perhaps the internal wall represents the chitinous tube, or model of the stomach filled with excrement, Darwin describes in the alimentary canal of Cirripedia.[2] In the full-grown male the stomach is almost empty; in a younger condition (Pl. IV. fig. 1), the stomach is filled

[1] O. and R. Hertwig, Die Coelomtheorie, *Jenaische Zeitschr.*, Bd. xv., p. 76, 1882.
[2] Darwin, Balanidæ, p. 86, 1854.

with a yellowish-brown coloured mass of a fatty nature. Between the two walls of the stomach, nuclei of nearly the same size as those of the connective tissue are visible.

Nervous System.—The supraœsophageal ganglion, also, has nearly kept its original position; it is situated against the œsophagus, a little anteriorly to the place where it communicates with the stomach. In Pl. I. fig. 2 it is figured in its natural position and condition; in Pl. III. fig. 5, and Pl. I. fig. 4, it is seen in transverse section; numerous rounded ganglionic cells are placed at the periphery, and the whole interior of the ganglion is occupied by the medulla. Pl. I. fig. 4 distinctly shows the commissures which serve to unite the ganglion with the large thoracic ganglion. In the preparation which is figured (Pl. I. fig. 2) these commissures could not be made out, nor has this been possible in any of the other preparations I made by the aid of needles.

This thoracic ganglion represents alone the whole ventral nerve-cord; together with the thorax, it has changed its place and has been transposed in a direction towards the front of the animal, so as to be now attached before the supraœsophageal ganglion; it has an elongate oval shape with numerous ganglionic cells at the periphery. In a transverse section such as that figured (Pl. I. fig. 5), we observe that the ganglionic cells form a much thicker layer on the side which is directed towards the thorax than on the other side; the lateral symmetry of the ganglion is very distinct, the medulla forming two rounded portions which meet in a straight line in the middle of the ganglion. The nerves given off from this ganglion as well as those from the supraœsophageal ganglion are extremely delicate and are hardly recognisable as such; two somewhat stronger nerves start from the commissures very close to the supraœsophageal ganglion, and a distinct nerve is attached terminally to the thoracic ganglion, but as for other nerves, I found it impossible to distinguish them with certainty from the fibres of the connective tissue.

There are no organs of sense; even the sense of touch can be only very slightly developed, as the whole body is enclosed within a chitinous bag bearing only chitinous spines on its surface. The hairs on the antennæ (Pl. I. fig. 3) no doubt once performed the function of organs of touch, but after the antenna has attached itself the function of these hairs can no longer be of any importance. Close to the supraœsophageal ganglion I always observed two little bodies which from their position I at first felt inclined to consider as belonging to the nervous system. They are kept in their places by the connective tissue, and they are situated near the corner between the stomach and the supraœsophageal ganglion. Their structure is that of an oval bag slightly pointed at one or both extremities, lined by an extremely delicate membrane and filled with a granular substance of a brownish-yellow colour, having numerous nuclei scattered throughout its interior (Pl. I. fig. 2, *gl.*). Most probably these organs represent the remains of the appendages of the œsophagus (Pl. II. figs. 1, 2, *C*) of the pedunculated Cirripedia, which are very distinctly developed in the

Cypris of *Lepas*, and which probably correspond to the salivary glands of Cuvier; that they are here as rudimentary and as functionless as the œsophagus and the stomach itself is an argument, though a negative one, in favour of my interpretation.

In some of the sections and preparations I observed globular elements which I think are blood-corpuscles. I have figured some of them Pl. IV. fig. 7. They have very distinct dark coloured nuclei and their size varies from 0·015 to 0·02 mm.; by their size alone they can be easily distinguished from the nuclei of the connective tissue.

From the condition of the mouth and the alimentary canal there can, I believe, be no doubt that these little animals never take food at all. For this reason it is necessary not only that the whole of the body with its well-developed genital apparatus develops from the yolk-mass in the Cypris-larva, but it must be supposed also that the little body can only furnish so much of the male genital product as may develop from the testis after it has once arrived at its full size and maturity. Probably therefore each male only once, or in one season with short interspaces, takes part in the act of propagation. And as it is highly probable that the species of *Scalpellum* like most other animals spawn only once a year, the male which has once furnished its quantum of the male genital product is to be replaced by another. The objection may be made that it is possible that only one part of the spermatozoid mother-cells develops into spermatozoids in one season, and a second part in a following year; but then it is difficult to understand, with our present knowledge of animal life, in what way the little animal is supplied with the material necessary for its maintenance.

The Male Organs.—The testis is heart-shaped with the incision directed towards the hinder or capitular extremity. Its length in some of the specimens was about 0·5 mm., in others, which themselves were longer, no less than 0·8 mm. In the latter case the incision was more than half as long as the organ.[1] This incision is remarkable, I believe, because it is the only sign of the original duplicity of the male genital gland.

The histological structure of the testis presents no points of special interest; the spermatozoid mother-cells have a size of 0·021 mm. and fill up the whole interior of the gland. They split into extremely small transparent cells with a dark-coloured little body for a nucleus. These small cells are 0·004 mm. in diameter and I think each of them develops into a spermatozoid. The wall of the testis is built up of connective tissue with nuclei of 0·01 mm. in diameter; the wall of the vesicula seminalis presents about the same structure. It is an irregularly globular vesicle, having in the full-grown and mature males a diameter of 0·3 mm.; it is very closely pressed against the testis.[2] In younger specimens I did not observe this organ; the vas deferens in them only presented a very small swelling at the place where it communicates with the testis; the

[1] The testis of *Scalpellum darwinii* when young does not show an incision; in older specimens, however, traces of an incision are present. Other species (*e.g. Scalpellum tenue*, Hoek) have the testis triangular with a heart-shaped foot.

[2] In other species (*Scalpellum tenue*, *Scalpellum darwinii*, &c.) the testis is separated from the vesicula seminalis by means of a duct of not inconsiderable length.

vesicula seminalis is no doubt only a dilatation of the vas deferens at the place where it corresponds with the testis. The vesicula seminalis in all the larger specimens was filled with a dense mass of very small spermatozoids; they have the shape of threads, each having a length of about 0·02 mm., and each furnished at the extremity with a very small vesicle (Pl. I. fig. 6). Between the spermatozoids in the vesicula seminalis small empty vesicles are seen, as also others which quite resemble the very small cells of the contents of the testis, probably each one of them contains a spermatozoid.

The length of the canal acting as a vas deferens is not very considerable; it passes freely through the connective tissue for about 0·25 mm. and then enters into that part of the body which represents the thorax of the Cirriped. Figs. 10 and 11 on Pl. III. show sections of the duct before it reaches the thorax, but in the figs. 5 to 8 of Pl. III. the same canal is represented in the middle of each transverse section of the thorax. In fig. 9 the form of the section of the thorax is nearly quadrangular; this is its shape near the place where the vas deferens enters it; in the sections, however, which more approach the other extremity of the canal the thorax is exactly cylindrical, and then its wall is parallel to the wall of the genital canal. The diameter of the thorax itself is about 0·08 mm.; the canal which runs through it longitudinally has a width of 0·03 mm. Whether it be preferable to designate the cylindrical terminal portion of the thorax as "penis" is I think difficult to say; morphologically it is hardly to be distinguished from the appendix of that name in the hermaphrodite Cirriped, which is called by some authors a penis, by others an abdomen.

The nuclei of the cells which surround this canal (Pl. I. fig. 5) are slightly larger than those of the connective tissue placed between the canal and the chitinous wall of the thorax; as far as I could distinguish in any of the sections, these cells of the wall of the canal have no distinct shape and do not compose a true epithelium. From the place where it enters into the thoracic part of the body the vas deferens is seen in all the sections which pass transversely through the thorax; it may be traced for about half a millimetre, it then ends abruptly; probably, though this could not be distinctly observed, it now opens into the cavity (Pl. III. fig. 4 *ca*) lined by the connective tissue, which has an outward opening at the capitular pole of the body. The communication with this cavity must be about at the height of the supraoœsophageal ganglion. The whole thoracic part of the body can be stretched forward in a direction towards the capitular pole; though I do not believe that the opening of the vas deferens ever reaches the opening at the surface of the body, this stretching forward of the thorax is no doubt brought about in order to approach the opening of the vas deferens as much as possible to the slit at the extremity of the body. Well-developed musculi retractores serve for the retraction of the thorax within the body of the male. I have figured one of them on Pl. I. fig. 1, *mr*. In the transverse section figured on Pl. III. fig. 10 these muscles are also represented.

The Appendages.—As far as the number and the shape of the appendages of the thorax are concerned, it has proved rather difficult to get any certainty; in the first place, because the limbs with their thin chitinous wall refract the light in the same way as the thorax, and are pressed so closely against the body of the thorax as to make it impossible, even in a well-stained preparation, to make out their respective outlines, and in the second place, because of the smallness of the parts in question. After a careful study of sections, as well as from preparations made by dissection with needles, I believe the following facts may be safely relied upon. Only four pairs of legs are relatively well-developed; these are the four posterior pairs, and each of them is composed of two branches. Of the first two pairs of cirri only one very short branch is left. Each branch of the double-branched ones is relatively long and narrow, and terminates in two or three very long spines. In a transverse section each leg is represented by its chitinous wall and by the nuclei of its matrix, which are more or less elongate (Pl. I. fig. 5).

The Cement-Glands.—Finally, I must describe in a few words the structure of the cement-glands. They may be best studied in a section of a not quite full-grown specimen, as shown in Pl. IV. fig. 3. Each male contains a pair of these glands; they are situated a little above the vesicula seminalis (Pl. I. fig. 1 *c. gl.*); they have an oval shape and measure about 0·15 mm. They are composed of very large cells with granular contents and a large nucleus, kept together by an extremely delicate network of connective tissue with a single rather small nucleus here and there between its fibres. Between the large cement-cells cavities are left open here and there in the connective tissue; each cell has the shape of a wedge, and is placed so that the broader part is directed towards the periphery, the narrower on the contrary towards the centre of the gland. The structure of the contents of each cell is rather remarkable, since the larger granules are placed at the periphery, and the contents are much more homogeneous towards the narrower extremity of the cell. In one of the preparations the ducts which run from the gland to the antennæ were rather distinct; they are attached as thread-like appendages to one of the narrower extremities of the gland.

Summary.—I think I have given herewith a full description of the so-called complemental male of a species of *Scalpellum.* With this description and with the figures on Pls. I.–IV. it is possible not only to prove that this male has a highly degenerated organisation, but also to demonstrate in what this degeneration consists, and how it affects some of the organs very greatly, whilst others suffer less from it, and some are not influenced by it at all.

The state of things in the male under consideration may be summed up as follows:—

1. The external characteristic shape of the species with its capitulum and peduncle, its valves and scales, is lost. The microscopic body consists of an elongate bag closed on

all sides. A very small slit represents the opening between the two scuta. The antennæ are the only extremities which still show their original condition; the cirri have grown straight and functionless; the parts of the mouth have disappeared.

2. The cement apparatus is well developed as long as the male is young; when mature it is no longer so distinct.

3. The intestine has become functionless and is quite rudimentary; circulatory and respiratory organs may be passed by, as they have no distinct organs even in the hermaphrodite *Scalpellum*.

4. The nervous system consists of a relatively small supra-œsophageal ganglion, of a not very stout œsophageal ring, and of a large thoracic ganglion. It is probably the latter which alone regulates the functions of the genital apparatus. The peripheral part of the nervous system is not much developed. The eyes (and other organs of sense) have been lost.

5. The genital apparatus is the only well-developed system of organs. The female apparatus, however, is totally lost, and even the male organs show a great deal more concentration than do the same organs in ordinary hermaphrodite Cirripedia. In the first place the testis is single, and has become a rather compact gland, whereas in other Cirripedia it is double and scattered throughout almost the whole interior of the body. In the second place, the vesicula seminalis is also represented by a single vesicle only, hermaphrodite Cirripedia on the contrary having always two of them.

In all these respects the little males of other deep-sea species of *Scalpellum* which I have been able to investigate exactly correspond to the male of *Scalpellum regium*. So does the male of *Scalpellum vulgare* (from specimens from the Mediterranean) with the exception of the presence of rudimentary valves, which in that species, as in some of the deep-sea species (*vide* p. 4), represent the so-called primordial valves of the young capitulum of pedunculated Cirripedia.

c. General Observations.

In the case of *Scalpellum vulgare*, Leach, *Scalpellum rostratum*, Darwin, *Scalpellum peronii*, Gray, sp., and *Scalpellum villosum*, Leach, sp., Darwin observed what he considered a penis; in *Scalpellum vulgare*, Leach, and in *Scalpellum villosum*, Leach, sp., he ascertained moreover the presence of vesiculæ seminales and testis in the specimens which were also furnished with ovaria. These specimens, therefore, were hermaphrodites, and as little males were found attached to their scuta, these male specimens got the very characteristic name of "complemental" males. On the other hand *Scalpellum ornatum*, Gray, sp., did not show a trace of a proboscidiform penis in the four specimens which Darwin examined, and he, therefore, supposes that the animals studied by him were females, although it was impossible, as the specimens were

dried, to demonstrate the absence of the vesiculæ seminales and testes. The male animals were lodged in a pouch on the under side of the scutum, in that case should not bear the name of "complemental" males. From the state of the specimens of *Scalpellum rutilum*, Darwin, which Darwin examined, it was quite impossible to ascertain whether the individual was a hermaphrodite or a female; from the analogy of its nearest congener *Scalpellum ornatum*, the latter, Darwin says, is the most probable.

Darwin's supposition as to the unisexuality of some species of *Scalpellum* proves to be in a very striking accordance with the facts. What I at first considered to be the hermaphrodite form of *Scalpellum regium* (Wyv. Thoms.), Hoek, is not furnished with a penis and does not show a trace either of a testis or a vesicula seminalis. To have full certainty in this respect, I divided the whole thoracic part of the body of a specimen of this species into a series of sections, and in none of them did even the smallest trace of a part of the male genital apparatus appear. The body was stained *in toto* by means of aluminium carminate, a most brilliant staining for the testis and for the spermatozoa within the vesicula seminalis when present. I then repeated the examination of *Scalpellum vulgare*, Leach; I found the animal a true hermaphrodite; it is furnished with a well-developed penis, and the vesiculæ seminales have exactly the structure of these organs in species of the genus *Lepas*. The only difference is shown in their small size. Slightly more developed testes pour out their products into the vesiculæ seminales.

The specimen of *Scalpellum regium*, of which I examined a series of sections, was a full-grown animal; it was furnished with males and there were ova in the ovigerous lamellæ. I got the same results when making a series of sections of *Scalpellum parallelogramma*, Hoek (Pl. IV. fig. 9), and *Scalpellum nymphocola*, Hoek (Pl. IV. fig. 10). So I think that we may safely draw the following conclusions:—

There are species of the genus *Scalpellum*, Leach, which show a very characteristic dimorphism. Some of these consist of large hermaphrodite and small rudimentary male specimens; others have large female and small rudimentary male forms.

However, I do not believe that these are the two most divergent cases in the sexual relations of the genus *Scalpellum*. I think there is still a third category of species in this genus, viz., those which are as true hermaphrodites as other Cirripedia, and in which no complemental males are developed. As a supposed species of this third division I will point out *Scalpellum balanoides*, Hoek. In the descriptive part of my report I have communicated the fact (p. 130) that one of the specimens contained eggs, though no complemental male was present at the place it ordinarily occupies. Though I have studied some more specimens of this species with great care, I have not once observed a male; yet they were nearly all furnished with eggs. I then studied the body of one of the specimens by the aid of transverse sections (Pl. IV. fig. 8, *a–f*); I found that the specimen was furnished with a very largely developed testis greatly surpassing the same organ in *Scalpellum vulgare*. The penis of this specimen was also of considerable

size. Suppose I had observed this same organisation in a species of another genus of Cirripedia, then I should never have thought the existence of a complemental male in that species possible, and now in the case of a species of *Scalpellum* I think I may safely infer that in this species the absence of a complemental male is not an accident, but indeed the rule! I think, therefore, that there is sufficient reason to conclude that the genus *Scalpellum* presents the three following stages of sexual differentiation :—

1st. True hermaphrodite species: all the specimens develop male genital products as well as female. Whether these species are also "autogames,"[1] *i.e.* whether the spermatozoa of a specimen as a rule fertilize the ova of the same specimen, is a point, which I do not wish to discuss at present. I will only say that in case "autofécondation"[1] should be proved in the case of other Cirripedia (which at present has not, I think, been done) we can also safely admit it in the case of these species of *Scalpellum.*

Example:—

Scalpellum balanoides, Hoek.

2nd. Large hermaphrodite specimens and small unisexual (male) ones in the same species.

A. Male specimens with a capitulum and peduncle, with a mouth and stomach.

Examples :—

Scalpellum villosum, Leach, sp. | *Scalpellum peronii*, Gray, sp.
(*Scalpellum trispinosum*, Hoek.[2])

B. Male specimens with or without rudimentary valves, without a peduncle, a mouth and stomach.

Examples :—

Scalpellum vulgare, Leach. | *Scalpellum rostratum*, Darwin.
(*Scalpellum acutum*, Hoek.[3])

[1] Robin, Ch., Article "Sexe" in Dictionn. encyclopéd. d. sci. med., Paris, 1880.

[2] The body of this species has not been investigated; so my conclusion is based only on the presence of a well-developed penis, and on the great resemblance of the species to *Scalpellum villosum*, Leach.

[3] This species has not been investigated either; the supposition as to its hermaphroditism is based only on the presence of a well-developed penis.

3rd. True unisexual species; the females are large, the males very small and (probably) short-lived.

Scalpellum ornatum, Gray.	*Scalpellum vitreum*, Hoek.
regium (Wyv. Thoms.) Hoek.	*moluccanum*, Hoek.
parallelogramma, Hoek.	*eximium*, Hoek.
nymphocola, Hoek.	*darwinii*, Hoek.
tritonis, Hoek.	*carinatum*, Hoek,[1] &c.

Of all the genera of Cirripedia, *Scalpellum* is no doubt the one which presents the greatest amount of variety as far as the sexual relations are concerned. In this regard it even surpasses the genus *Ibla*, Leach, of which we know, through the aid of Darwin, that it presents two instances of sexual differentiation only, viz., unisexuality in the one species and hermaphroditism with accompanying rudimentary males in the other. It is well known that the genus *Scalpellum*, by means of *Scalpellum villosum*, Leach, sp., and by means of *Scalpellum trispinosum*, Hoek, blends with the genus *Pollicipes*, Leach, and also that the latter genus is one of the oldest, if not the oldest, of the genera of Cirripedia. All the known species of *Pollicipes* are true hermaphrodites as are other Cirripedia, and moreover, *Pollicipes* seems to be a genus which only contains shallow-water species. With a little imagination it does not appear to be very difficult to trace the way in which sexual differentiation took place in the genus *Scalpellum*. Originally there were only hermaphrodite species, inhabitants of shallow-water. They resembled more or less the species of the genus *Pollicipes*. In some of the species specimens attached themselves to each other[2] as well as to other objects, and they developed all into ordinary hermaphrodite specimens. In one of these species, however, young specimens attached to full-grown older ones, though developing into animals of the ordinary shape with a capitulum and a peduncle, did not acquire the size of the older specimens and lost their female genital apparatus. In a following stage, we see that the little creatures which by their smallness are enabled to hide within the valves of the older hermaphrodite specimens, lose their valves and are reduced to a rudimentary state in all respects, except so far as the male organs are concerned. Finally we observe in the latest stage that the original hermaphrodite specimen loses its male genital apparatus and becomes unisexual. In the latter species we have large and relatively long-lived female specimens, and small and short-lived males.

I feel sure that some serious objections may be advanced against this reasoning, and

[1] The bodies of *Scalpellum tritonis*, *Scalpellum vitreum*, *Scalpellum moluccanum*, *Scalpellum eximium*, *Scalpellum darwinii*, and *Scalpellum carinatum*, have not been investigated by means of transverse sections. Their unisexuality is based only on the total absence of a penis and on their general resemblance to the investigated unisexual species.

[2] Specimens of *Scalpellum vulgare* are attached to various horny corallines, and occasionally to the peduncles of other individuals. Darwin, Lepadidæ, p. 226, 1851.

one of these I will point out myself. Those species which are unisexual and have very small and rudimentary males, which, therefore, according to the sketch given above, are the youngest of the hypothetical course in which the different stages of sexual differentiation have developed, are at the same time those which closely resemble the species from the oldest geological strata from which species of *Scalpellum* are known. But I think this objection is weakened by admitting that the sexual differentiation in the genus *Scalpellum* was already achieved at the period from which these fossil remains date. The somewhat aberrant shape of *Scalpellum balanoides*—the species in the supposed original condition of true hermaphroditism—is also difficult to explain at first sight. We might have expected to observe the original condition (hermaphroditism without complemental males) in a species as closely resembling *Pollicipes* as possible, as for example in *Scalpellum villosum*, Leach, sp.; or *Scalpellum trispinosum*, Hoek.[1] The condition of the genital apparatus and the external shape of the valves (the whole capitulum), however, are two factors which need not necessarily stand in so very close a relation to each other. So it may be easily imagined that the original condition of the sexual apparatus is left in a form in which the external shape of the capitulum has been altered, and on the other hand there is no reason why the sexual relations of a form should not become altered without the external shape undergoing considerable changes at the same time.

When, however, all these considerations are weighed I do not believe that there are trustworthy grounds for doubting the exactness of the hypothesis that in the genus *Scalpellum* the hermaphrodite condition is the original, and the unisexual, the secondary stage in the development.

[1] I did not observe the male of *Scalpellum trispinosum*. I suppose that this species is furnished with a complemental male with capitulum and peduncle from its resemblance to the species *Scalpellum villosum*. I did not study its genital apparatus. I can only say that it is furnished with a well-developed penis.

II. SEGMENTAL ORGANS IN THE CIRRIPEDIA.

Cirripedia are rich in organs of an unknown or at least problematic function. One instance of these is found in the "olfactory organs" or sacs of Darwin. "In the outer maxillæ," Darwin says,[1] "at their bases where united together, but above the basal fold separating the mouth from the body, there are, in all the genera, a pair of orifices; these are sometimes seated on a slight prominence, as in *Lithotrya*, or on the summit of flattened tubes projecting upwards and towards each other as in *Ibla*, *Scalpellum*, and *Pollicipes*. In *Ibla* these tubular projections rise from almost between the outer and inner maxillæ. It is impossible to behold these organs, and doubt that they are of high functional importance to the animal. The orifice leads into a deep sack lined by pulpy corium, and closed at the bottom. The outer integument is inflected inwards (hence periodically moulted) and becoming of excessive tenuity, runs to near the bottom of the sack, where it ends in an open tube; so excessively thin is this inflected membrane, that until examining *Anelasma*, I was not quite certain that I was right in believing that the outer integument did not extend over the whole bottom. I several times saw a nerve of considerable size entering and blending into a pulpy layer at the bottom of the sack of corium; but I failed in tracing to which of the three pair of nerves, springing from the front end of the infraœsophageal ganglion, it joined. I can hardly avoid concluding that this *closed* sack, with its naked bottom, is an organ of sense; and, considering that the outer maxillæ serve to carry the prey entangled by the cirri towards the maxillæ and mandibles, the position seems so admirably adapted for an olfactory organ, whereby the animal could at once perceive the nature of any floating object thus caught, that I have ventured provisionally to designate the two orifices and sacks as olfactory."

This supposition of Darwin's has, however, been accepted with great reserve. As far as my knowledge of the literature of the group goes, the same organs have not been studied, nor has another opinion been published about their function since Darwin's.[2] I first tried to get a good insight into the structure of this apparatus by isolating the outer maxillæ. I arrived at the same conclusion as Darwin, viz., that it was composed of a duct with an outward orifice and an internal portion, a kind of sac lined by a layer of cells different in structure from those of the duct. In some of the figures representing parts of the mouth of species of the genus *Scalpellum* (*e.g.* *Scalpellum parallelogramma*, *Scalpellum strömii*, &c.), in the systematic part of my report, the long and very characteristic tubes at the extremity of which the orifices are found have been represented. I then studied the apparatus by the aid of transverse sections of the thorax of the

[1] Darwin, Lepadidæ, 1851, p. 52.

[2] Claus (Lehrb. d. Zool. 3 Aufl. 1876, p. 456, says:—"Gehör- und Geruchsorgane sind nicht mit Sicherheit nachgewiesen, da die von Darwin als solche in Anspruch genommenen Bildungen eine andere Deutung (Oviducte, Drüsenöffnungen) erfahren haben." I do not know where this opinion has been published, so far as Darwin's olfactory organ is concerned.

animals, and I then became certain that Darwin's description was not correct in one very important regard. The sack is not closed at the bottom, but gives entrance to the body cavity of the animal.

For want of material I have been obliged to limit my researches to the pedunculated Cirripedia; in the sessile Cirripedia, however, there cannot be the slightest doubt that the apparatus will prove to have about the same structure; the orifices are here never produced nor tubular.[1] I got by far the best preparations from specimens of *Scalpellum vulgare*, Leach, which I received from the Zoological Station at Naples. The figures on Pl. V., as well as the description, are based upon preparations of these specimens.

Fig. 1 of Pl. V. shows a complete transverse section through the thorax of *Scalpellum vulgare* a little below the first cirrus. The large cavities (*A*) separated in the figure from one another by the band of connective tissue (*B*) represent parts of the body cavity. An epithelial clothing (a true cœlomic epithelium) cannot everywhere be made out distinctly; yet I think its presence may be safely concluded from the cellular remains which here and there adhere to the connective tissue, in the shape of elongate and rather flat nuclei. The section passes longitudinally through the long and flattened tube which belongs to the right outer maxilla; the duct on the interior is clothed by a thin chitinous tunic, with a chitinogenous epithelium everywhere beneath it; both the chitinous tunic and its matrix are the continuation of the outer body-wall and are no doubt true epiblastic products. Fig. 3 of Pl. V. represents a longitudinal section of one of the segmental organs. From the outer wall of the flattened tube thin transverse fibres of connective tissue run towards the wall of the duct. Having passed longitudinally through the tube, the duct may be traced for a short distance beneath the surface of the body; it then passes over into a very narrow channel which passes through a compact mass of cells. The whole mass of cells has the shape of a bell; the limits of the different cells are not very distinct, but the different nuclei are. They are oval and their longest diameter is about 0·005 mm. (fig. 2, Pl. V.) The surface of the cells bordering the narrow channel is markedly protuberant, so as almost to meet that of the opposed cells; in very favourable sections only can the presence of the channel be made out. To judge from the great number of nuclei, the cell-mass, at least on one side, is formed of more than a single layer. Whereas the cells of the duct have their nuclei with their longer axis parallel to the surface of the wall of the duct, those of the bell-shaped cell-mass are rather perpendicular to the surface of the very narrow channel. Moreover, the latter are very characteristic on account of their staining much more intensely than do those of the chitinogenous cells or of the surrounding connective tissue. Towards the interior of the body-cavity the thick cell-coating of the narrow channel slopes and soon terminates; from the body-cavity the entrance of the narrow channel is distinctly funnel-shaped. The chitinous membrane which clothes the interior of the duct is not present at the surface of

[1] Darwin, Balanidæ, 1854, p. 97.

the cells which border the narrow channel. (Probably we have here the explanation of what Darwin means, when he says that the outer integument is inflected inwards, and ends in an open tube).

I propose to call the duct which opens at the extremity of the tubes the segmental duct, and the bell-shaped cell-mass with its very narrow channel the segmental funnel. I think we can hardly hesitate to consider these organs as true segmental organs, but before entering into a discussion of the arguments in favour of this suggestion, I will finish the description. To the apparatus belongs also a well-developed set of muscles attached round about to the external surface of the bell-shaped cell-mass, and especially those directed to the external side of the body, are very strongly developed; they form towards the interior of each organ a nearly triangular mass, the apex of which is directed towards the interior of the body, the broad basis being placed against the outer surface of the bell-shaped cell-mass (Pl. V. fig. 2). The muscle-fibres of the external side of the cell-mass are distinctly divergent, and a part of them continues in a rather strong bundle of muscle-fibres running towards the border of the body-cavity. In my most successful, thinnest, and best stained preparations the muscle-fibres did not show transverse striation; those especially of the external side were remarkable for their clearness and smoothness, resembling thin elastic fibres of the connective tissue. Between these fibres interspaces may be seen everywhere, and in these numerous pale small round cells were visible, which I think were blood-corpuscles. Probably the function of the muscle-fibres is not in the first place to move, but to form a labyrinth of small cavities in which the blood accumulates.

What may be the morphological significance of this organ? Considering that it constitutes an open communication of the body-cavity with the exterior, there can be no doubt that it must be compared with the segmental organs of the Annelida. The high development in the genus *Scalpellum* of the flattened tube at the end of which the orifice is found, shows, I think, that we have not before us a rudimentary organ, but an apparatus of an important functional significance. From a phylogenetic point of view its importance increases with our knowledge of the great age of Cirripedia, of which *e.g.* the present genus is already represented in the Lower Greensand. Where the shell has remained exactly the same, we can safely admit that the structure of the animals is sure to have changed very little or not at all since that remote geological period.

A rather curious circumstance is found in the fact that in Cirripedia only one pair of segmental organs has remained. In the oldest Tracheate Arthropoda we know of (*Peripatus*), according to Balfour,[1] there are found nephridia or segmental organs in all the legs; in Crustaceans these same organs have not been observed with certainty; the only instance mentioned in literature is that of terrestrial Isopods, where M. Huet[2]

[1] F. M. Balfour, The anatomy and development of Peripatus capensis, *Quart. Journ. Micr. Sci.*, vol. xxiii. pp. 213–259, 1883.

[2] Huet, Sur l'existence d'organes segmentaires chez certains Crustacés isopodes, *Comptes Rendus*, 1882, No. 12, p. 810.

believes he has observed segmental organs in each of the seven body segments. Whether M. Huet be right in considering these organs "organes glandulaires . . . qui s'ouvrent à la partie supérieure des épimères, de chaque côté, par une ouverture en crible" as segmental organs, I will not discuss. To judge from his description they have not the typical structure of true segmental organs which are to form an open communication between the body-cavity and the exterior.

Two other sets of glands of Arthropoda, and more especially of Crustaceans, are perhaps more nearly related to the segmental organs; they are the antennal glands of the larvæ of many Entomostracans and of the full-grown Malacostracans; and the shell-glands of full-grown Copepoda and Phyllopoda. According to Grobben[1] they have nearly the same structure and must be regarded as homologous organs (homodynamous they are called, more accurately I think, by R. and O. Hertwig[2]); both are composed of a little terminal sack (Endsäckchen), and a channel (Harnkanälchen) which opens at the surface of the body. Moreover, the cells covering the interior of the little sack in the antennal and shell-glands show a complete resemblance. An open communication with the body-cavity has, however, never been observed in the case of these organs[3]; if they really are to be compared with segmental organs, there can be no question that they have degenerated from their original condition.

Should there ever be discovered an intermediate form between a true segmental organ such as that of *Scalpellum* and a shell-gland as observed in the Copepoda, then in the first place the homology of the apparatus may be accepted; but in the second place it will then also be possible to give a more solid basis for demonstrating the homologies of the extremities of Cirripedia and Copepoda than has been the case hitherto. When treating of the female genital apparatus and its orifice at the base of the first cirrus I hope to point out that there is sufficient reason for admitting that a second pair of segmental organs, though in a slightly modified condition, is present in the Cirripedia also.

Finally, I will not take leave of this subject without stating as my opinion that the segmental organ which I have described is physiologically an organ of an excretory nature. The condition of the material at my disposal did not allow of my attempting a chemical investigation of the contents of the cells, and so it is only from analogy that this conclusion has been arrived at. It is fairly supported, I think, by the presence of muscle-fibres with numerous cavities between them, such as have also been observed by Grobben (*loc. cit.*, p. 105) in the neighbourhood of the antennal glands of the Decapoda.

[1] C. Grobben, Die Antennendrüse der Crustaceen, *Arb. Zool. Inst. Wien.* Bd. iii. 1880.

[2] R. and O. Hertwig, Die Cœlomtheorie, *Jenaische Zeitschr.* Bd. xv. pp. 1–150, 1882.

[3] According to Sedgwick (*Quart. Journ. Micr. Sci.*, vol. xxiv. N.S., pp. 46, 47, 1884), the nephridia of the Invertebrata are developed from solid masses of cells derived from the wall of the cœlom; a communication with the body-cavity in that case would represent a secondary stage.

III. THE CEMENT APPARATUS.

The cement apparatus and the genital organs of the Cirripedia are in general tolerably well known; in detail, however, our knowledge often proves to be very insufficient. Darwin has the merit of having discovered the presence of the cement apparatus, but he failed to understand its organisation, partly because he confounded its elements with those of the female genital apparatus.

Krohn[1] gives a much more accurate description of the cement apparatus of *Lepas anatifera* and *Conchoderma virgatum*. He was the first to observe the true cement-glands. In *Lepas anatifera* they are, according to him, situated in the most superior part of the peduncle and scattered through the connective tissue which envelops the ovary; they are very numerous and they have the shape of long oval, vesicular little bodies, which are attached to very delicate and richly ramified canals in the same way as berries to their stems. These canals open, before the inferior extremity of the ovary is reached, into the two cement-ducts, the commencements of which are swollen into ampullæ. These cement-ducts have been already observed by Darwin; they run downwards at a considerable distance from one another, one at the right, the other at the left hand side of the peduncle, and they are situated close to the innermost layer of longitudinal muscle-fibres. Finally they penetrate into the chitinous wall of the peduncle near the place where it is attached; they pass through this wall, becoming narrower and narrower, and are then lost sight of. In the deeper layers of the chitinous wall of the peduncle the cement-ducts are invested with rounded swellings of different sizes, which are hollow and which are doubtless in open communication with the ducts; these swellings act as reservoirs to retain the cement before it is evacuated. In *Conchoderma virgatum* the cement-apparatus differs from that of *Lepas anatifera* in the cement-glands being for the greater part placed in the parenchymatous tissue of the mantle and for a very small part only in the superior extremity of the peduncle. The two cement-ducts with their swollen ampullæ reach very close up to the place where the capitulum communicates with the peduncle. The two ampullæ in this genus communicate with one another by means of a transverse and tortuous canal.

I studied the cement apparatus in *Lepas*, *Conchoderma*, and *Scalpellum*. As regards the histological structure of the apparatus my researches are far from satisfactory, the condition of the material at my disposal being, in part at least, the cause of this. The peduncle of the Cirripedia is very difficult to preserve; even in specimens freshly sent over by the Direction of the Zoological Station at Naples, the condition of the tissue has suffered much.

The little bodies which were considered by Krohn as the true cement-glands must

[1] A. Krohn, Beobachtungen über den Cementapparat und die weiblichen Zeugungsorgane einiger Cirripedien, *Archiv. f. Naturgesch.* Jahrg. xxv. Bd. i. pp. 355–364, 1859.

indeed be regarded as such. Krohn has not given a description of these glands, nor is such a description to be found in the literature of the group. For *Balanus* I myself published figures of these glands some years ago,[1] when it was my opinion that the ovarian cœca might perhaps develop from these bodies—a serious error pointed out by Claus. My excuse was firstly that these bodies, scattered everywhere between the young ovarian cœca, had never been observed in a sessile Cirriped before, and secondly that Darwin had led me into error by describing the cement-glands as adhering to the basal membrane or basal calcareous plate of the Balaninæ. I should have paid more attention to a foot-note in Krohn's paper (p. 357) in which he states his opinion, that the true cement-glands of the Balanidæ might also be found between the ovaries or in the connective tissue surrounding the mantle.

The cement-glands of *Lepas anatifera*, of *Conchoderma virgatum*, and of *Scalpellum vulgare* are nearly the same shape and size. Those of *Lepas anatifera* are a little larger, the longest diameter measuring 0·15 to 0·2 mm., whereas those of *Scalpellum vulgare* are smaller, having a diameter of about 0·125 mm. (The largest diameter of one of the cement-glands of *Balanus improvisus* is not quite 0·2 mm.). The interior of the cells is filled with a plasmatic mass, which shows the curious property of staining rather intensely with aluminium carminate. At the same time the large nucleus, which occupies nearly the centre of the cell and which measures half the length of the cell itself, is coloured also and much more intensely. In many preparations the body of the cell shows an extremely delicate granular structure, whereas the nuclei are coarsely granulated, or appear to have a fibrillar structure. In *Lepas* nucleoli have not yet been observed. Pl. II. fig. 5 shows the condition of the cement-cells in the Cypris-larva. I do not quite understand in what way the pear-shaped gland develops from these cells. The size of the latter is about 0·03 mm., at least in the case of *Lepas australis*. Towards one side, and as a rule in the longer axis of the cell, its wall is produced so that the cell becomes the shape of a pear; this produced part slopes into a long and narrow duct (Pl. V. fig. 5). The structure of this duct is very simple; here and there small cells are visible in its wall (measuring about 0·005 mm.), which on the exterior is lined by a kind of thin cuticle.

The ducts of the different cement-glands unite together to form a much more capacious duct; a little before the place where the junction is observed, a transverse short duct often runs from one branch to the other; all the ducts together form an irregular network, the thickest branches finally pour out their contents into two longitudinal ducts. The ducts (fig. 5, *d*), which communicate directly with the glands, have a diameter of about 0·025 mm.; the two longitudinal ducts in which the contents of the narrow ducts are evacuated, measure about 0·05 mm. in width. In a

[1] P. P. C. Hoek, Zur Entwickelungsgeschichte der Entomostraken, I. Embryologie von Balanus, *Niederländ. Archiv. f. Zool.*, Bd. iii. pp. 47–82, 1876.

large series of sections of the peduncle of *Lepas anatifera*, the presence of the principal cement-ducts can everywhere be ascertained; in the most superior part of the peduncle they run at a somewhat greater distance from the innermost layer of longitudinal muscle-fibres than is the case in the more inferior sections of the peduncle. The ampullæ which would represent the commencements of the cement-ducts I have not observed. The two ducts run in a zig-zag line, whence in many sections parts of them 0·3 mm. in length are represented. I have not been able to follow the cement-ducts quite up to the inferior extremity of the peduncle. The wall of the duct itself is irregularly folded in all my preparations of *Lepas anatifera*; towards the interior of the canal it seems to be invested with a thin cuticle, for, when a transverse section is studied, its interior is always limited by a sharp smooth line; for the rest, I have not a very clear notion of the cellular structure of the canal. The condition of the specimens of *Conchoderma virgatum* at my disposal has only allowed of my making a preparation of the glands. They are very small, measuring not quite 0·06 mm. Their nuclei are nearly circular and have a diameter of about 0·024 mm. In one of the glands a little nucleolus was visible, though not very distinctly. The thin cuticle which invests the canal that passes away from the gland in *Conchoderma virgatum* was visible also round the glands themselves. I found Krohn's statement as to the occurrence of the cement-glands for the main part in the parenchymatous tissue of the mantle to be quite correct.

In *Scalpellum* I studied the cement-apparatus in two species in greater detail; viz., in *Scalpellum vulgare*, Leach, and in *Scalpellum regium* (Wyv. Thoms.), Hoek. In these two species this apparatus is, curiously enough, not quite built up after the same type. That of *Scalpellum vulgare* has been described already by Darwin.[1] In young specimens, Darwin says, the attachment is performed by cement proceeding exclusively from the antennæ of the larva; in older and full-grown specimens the cement is poured out through a straight row of orifices along the rostral edge, thus causing a narrow margin to adhere firmly to the thin and cylindrical branches of the coralline. "At each period of growth the corium (the soft flesh, the mass of connective tissue with the muscles of the peduncle) recedes a little from the attached portion of the peduncle; of which portion the greater part is thus left empty, &c. . . . The two cement-glands are seated high up on the sides of the peduncle; the two cement-ducts proceeding from them, are $\frac{3}{2000}$ths of an inch (0·039 mm.) in diameter and run in a zig-zag line; at the point where they pass through the corium to enter the lower attached portion of the peduncle they become closely approximated, and partially imbedded in the membrane of the peduncle. Together they run along the rostral edge, giving out through each orifice a little disk of brownish cement, and finally they enter the larval antennæ."

The specimen of *Scalpellum vulgare*, whose cement-apparatus I have investigated, had a peduncle of about 9 mm. in length, and was attached by its under surface

[1] Darwin, Lepadidæ, 1851, p. 226.

to the rather broad stem of a horny coral. In order to be able to make transverse sections of the peduncle I have removed the chitinous wall of the peduncle with its calcareous scales. I stained the peduncle *in toto* by means of aluminium carminate. The ovary in this specimen was very strongly developed and its cœca extended as far as the most inferior part of the peduncle. The true cement-glands have nearly the same shape and structure as in the other genera; in size they are larger than those of *Conchoderma*, but not so large as those of *Lepas*. They are rather numerous in the superior part of the peduncle but become scarce lower down (Pl. V. fig. 6). On opening a peduncle of *Scalpellum vulgare* in alcohol, the glands appear as little white grains and are visible even with the naked eye. Often the glands are not unicellular but composed of two or three cells combined; in that case the body of the gland is larger and the two or three nuclei of the original cells are distinctly visible. In many of the glands a dark coloured oval nucleolus was present within the circular nucleus (Pl. V. fig. 6*); the size of the gland was 0·11 to 0·125 mm. in diameter, that of the nucleus 0·04, whereas the nucleolus measured 0·013 mm. The ducts at the end of which the glands are observed are very narrow, their diameter being about 0·007 mm.; those of adjoining glands often anastomose, so as to form together a network of ducts. I know these anastomosing canals from a preparation stained with picrocarmine and isolated by the aid of needles. In the transverse sections of the peduncle only very small parts of the ducts are seen attached to the glands.

All the narrow ducts pour their contents into four rather wide canals which at the rostral side run longitudinally through the peduncle. Immediately below the place in the superior part of the peduncle, where the two oviducts terminate, the first longitudinal cement-duct begins (Pl. V. fig. 6, *d*). It is closed at its superior extremity, the cement being shed in the canal by means of lateral openings. The blind extremity of the canal is placed a little more towards the centre of the peduncle; the canal slightly changes its direction so as to run parallel with and close to the elongated cavity (fig. 6, *a*) which is visible at the rostral side of most pedunculated Cirripedia (*Lepas*, *Conchoderma*, *Scalpellum*) and which is a continuation of a part of the body cavity of the animal within the capitulum. The width of the cement-duct is about 0·3 mm. It is surrounded by a chitinous wall—perhaps the chemical composition is different from that of chitin—and it shows traces of an epithelial (or rather endothelial) cell-layer on the internal surface. About half-way along the peduncle a second longitudinal canal begins; it has when seen in transverse section a long oval shape, and is divided by a partition into two halves which soon become independent. A little lower a third—properly speaking a fourth—canal begins (Pl. V. fig. 7). It has an oval shape; its largest diameter is 0·4 mm., its shortest 0·28; its wall is composed of a chitinous (?) outer layer and a regularly developed inner epithelial layer of very small cells with distinctly coloured nuclei. I do not quite understand why this epithelial cell-layer is well developed (at least distinctly visible) in the one duct, whereas it can scarcely be made out in the other ducts.

After the four canals have run independently of one another for about $1\frac{1}{2}$ mm., the first duct unites with one of the two ducts into which the second canal has divided, whereas the other half of the second duct terminates by uniting with the third. In the lowest sections of the peduncle of *Scalpellum vulgare* which I have been able to investigate, two ducts only are present. They run close to one another, and are placed within the wide canal which in the peduncle represents the cœlom. Of course higher up in the peduncle they were situated in this canal also; but at the place where they commence with a blind extremity, as a rule, they are not within this cavity. All the canals have very irregularly folded walls, and are filled up with a solid mass of a granular structure. Probably this is the cement after it has been affected by alcohol and reagents. At many places, part of the chitinous (?) and irregularly folded wall is stained also by the aluminium carminate.

The way in which the cement is poured out into the canals has not been observed by me. Everywhere round the canals a dense layer of connective tissue with numerous nuclei is observed, and at the places where the wall of the ducts is open, a spongy mass of this tissue penetrates within the opening. Most probably the connective tissue is charged with the duty of conducting the cement till it comes within the canals. The communication of the microscopic canals, at the end of which the glands are placed, with the cement-ducts—or with the connective tissue surrounding these ducts—has not been observed. I think it impossible to observe this without the aid of very rich and fresh material.

The cement-glands of *Scalpellum regium* (Wyv. Thoms.), Hoek, are not numerous, but they are relatively large. They are placed in two groups in the superior part of the peduncle to the right and to the left side (Pl. V. fig. 8). As a rule, each gland is composed of three or four glandular cells (Pl. V. fig. 11). I measured a gland which appeared to me to be unicellular, and its greatest diameter was 0·5 mm.; another composed of three cells had a length of 0·7 mm. The nuclei in the glands of this species have a very characteristic fibrillar structure; it is, of course, possible that the reagents have caused this. The ducts going off from the cells are narrow (their diameter being 0·016 to 0·02 mm.); the nuclei of the cells forming their walls are very distinct. The walls of these ducts are not quite smooth; globular vesicles adhere to them as small excrescences, and so give the duct, especially when studied in transverse section, a very curious aspect (Pl. VI. fig. 3). The ducts unite together so as to form groups of nearly parallel ducts, but often many of them retain their independence. Often two groups of ducts reunite, to become isolated again after a short time. About the middle of the peduncle I counted more than twenty groups of these ducts; some were composed of three or four single ducts, others of more (Pl. V. fig. 10). In the centre of each group of ducts often a much wider duct is visible; especially wide is a duct which runs at the rostral side of the peduncle close to the innermost layer of muscular fibres (Pl. V. fig. 10; Pl. VI. fig. 3).

This wide duct may be seen to continue as far as the uppermost part of the peduncle,

and is nothing else but the cavity (A) which we observed also in the peduncles of the other Lepadidæ, and which can be traced as a continuation of a part of the cœlom. In the superior part of the peduncle (Pl. V. fig. 8) this wide canal (measuring here 0·9 by 0·56 mm.) has an oval shape, and is completely filled with a very delicately granulated mass, which I think more resembles blood serum than any other substance. The connective tissue surrounding this canal, and especially the interior of the peduncle, has a very spongy structure; as I shall point out again when treating of the development of the ovaries within the peduncle, I think the contents of the duct and the tissue which surrounds it serve to nourish the ovaries.

At a short distance—about 3 mm.—from the superior extremity the duct begins to get narrower; the space occupied by the delicately granulated substance measures now only 0·22 mm. in diameter. The spongy mass of connective tissue has grown much thicker, and forms especially towards the interior of the peduncle a very thick wall; for the first time here cement-ducts are seen within this thickened portion of the wall of the duct (Pl. V. fig. 9). Between this wall and the central mass of the granulated substance a layer of vesicles can be distinguished. I think they are formed by the cement poured out into the canal and pressed between the wall and the central mass. One millimetre and a half farther down the duct becomes still narrower; it now has with its wall a diameter of 0·43 mm. only. The granulated substance has almost totally disappeared, but the interior of the wall is everywhere covered with large and small cement vesicles. Below the middle of the peduncle at numerous places, larger cement-ducts pour out their contents into this canal, which eventually has in all respects the shape of one of the wider cement-ducts such as are found also in the interior of the peduncle. In the undermost part of the peduncle it runs no longer close to the rostral side, but is observed in the centre of the peduncle. It there quite resembles two other larger cement-ducts which run longitudinally through the peduncle. Probably these ducts are open at their inferior extremities, which, as far as I could make out, are not continued up to the base of the peduncle; the latest sections I prepared of the peduncle do not show the ducts in the connective tissue.

So we see that in *Scalpellum regium*, the cement-ducts do not run within the cœlom-cavity, or what I feel inclined to consider as its homologue, but that this cavity in its most inferior part is itself changed into such a cement-duct. The other ducts stand in open communication with the one at the rostral side. A second difference is seen in the structure of the wall of the ducts; the smooth-lined sheath of the ducts in *Scalpellum vulgare*, which made me compare the substance of which that wall is built up with chitin, is nowhere to be observed in *Scalpellum regium*. No doubt the investigation of other species of *Scalpellum* and of other genera of Cirripedia will show that the cement-apparatus of this group of Crustaceans presents many more variations than would have been expected beforehand. The knowledge of these variations is no doubt of great interest, yet it would be of much more importance still, if the morphological significance of the apparatus were more apparent.

IV. DARWIN'S "TRUE OVARIA."

Darwin[1] observed in the Cirripedia two glandular masses resting on the upper edge of the stomach, and touching the cœca where such exist; these were thought by Cuvier to be salivary glands. They are of an orange colour and form two parallel "gut-formed" masses. Darwin was not able to ascertain whether the two main ovarian ducts coming from the peduncle expanded to envelop these glandulæ or what the precise connection was. He says "the state of these two masses varied much; sometimes they were hollow, with only their walls spotted with a few cellular little masses; at other times they contained or rather were formed of more or less globular or finger-shaped aggregations of pulpy matter; and lastly, the whole consisted of separate pointed little balls, each with a large inner cell, and this again with two or three included granules. These so closely resembled in general appearance and size the ovigerms with their germinal vesicles and spots, which I have often seen at the first commencement of the formation of the ova in the ovarian tubes in the peduncle, that I cannot doubt that such is their nature. Hence I conclude that these two gut-formed masses are the true ovaria. I may add that several times I have seen in the two long unbranched ducts, connecting the true ovaria and the ovarian tubes in the peduncle, pellets of orange-coloured cellular matter (*i.e.*, ovigerms) forming at short intervals little enlargements in the ducts, and apparently travelling into the peduncle."

In the second volume of Darwin's Monograph,[2] the same opinion as to the nature of these glandular bodies was given for the sessile Cirripedia. This opinion, however, was not only opposed to that of Cuvier[3] but also to that of Martin-Saint-Ange and of Karsten. Martin-Saint-Ange[4] describes "une espèce d'appendice stomacal, un véritable prolongement renflé et bilobé, communiquant avec la première cavité de l'estomac par un pédicule étroit et fort court. La structure, la forme générale, la coloration et la disposition mamelonnée de la surface extérieure de cette partie sont tout à fait semblables à celle de l'estomac, et doivent être regardées comme faisant partie du même organe." Martin-Saint-Ange, therefore, cannot be said to have considered these bodies as salivary glands, since he points out in his Memoir as well as in the explanation of the figures that these organs communicate with the stomach. So Darwin's objection "that salivary glands have not been positively recognised in any Crustacean" cannot be considered of any consequence.

Krohn,[5] describing the direction followed by the oviducts, says that they approach very

[1] Darwin, Lepadidæ, 1851, p. 57.
[2] Balanidæ, 1854, p. 100.
[3] Cuvier, Mémoire sur les animaux des Anatifes, *Mém. Mus. Hist. Nat.*, t. ii., 1815.
[4] Martin-Saint-Ange, Mémoire sur l'organisation des Cirripèdes, *Mém. Inst. Savans. Étrang.*, t. vi., 1835.
[5] Krohn, Ueber d. Cement-und Zeugungsapparat d. Cirripedien, *Wiegmann's Archiv*, t. xxv., 1859.

close to those organs "die seit Cuvier für die Speicheldrüsen gelten." For the rest he does not say what is his own opinion in regard to the nature of these bodies.

I do not think that since the publication of Darwin's Monograph these organs have been investigated; so I was most anxious to study them, and if possible to make out their structure. They occurred in all the genera in which I sought for them; I studied them in greatest detail in the genera *Lepas* and *Scalpellum*.

Near the place where the œsophagus communicates with the stomach, the outer surface of this latter organ is invested with a pair of oval masses; they are placed at rather a considerable distance from one another, one being found at the right, the other at the left hand side of the stomach. Pl. VI. fig. 7 shows their situation in *Lepas anatifera* when seen laterally, fig. 8 when seen from the anterior (dorsal) side. In both figures *Œ.* represents the œsophagus and *G. S.* the supraœsophageal ganglion; *p. n.* are the two strong peduncular nerves which start from the supraœsophageal ganglion; *oc.* is the curious eye discovered by Leidy, placed close to the surface of the stomach and separated from the external surface of the body by a very darkly pigmented integument and a thick layer of muscles, which are both left out in the figures. The oviducts (*ov*) are also distinct in both figures. They come from the peduncles and for some distance run parallel to the peduncular nerves; a little beyond the eye they are seen to diverge and then may be followed running transversely over or at least close to the surface of the stomach. Dorsally from the oviducts (in fig. 7 beneath them) the most anterior parts of the testis (*t*) can be distinguished. That part of the surface of the stomach which is nearest to the œsophagus is covered all over with rounded and dark-coloured tubercles (*l*) which cause the "disposition mamelonnée" of Martin-Saint-Ange, and which when studied in a transverse section appear to be the arborescent cœca of the surface of the stomach. The internal surface of these cœca is darkly pigmented and this causes the blackish colour of the rounded swellings at the exterior.

The glandular bodies in figs. 7 and 8 are marked *gl.* They are not always the same shape and size. Sometimes they are rather regularly oval and compact, having a length of about 4 mm. and a breadth of not quite 2 mm. In other cases, however, finger-shaped excrescences (as observed by Darwin) give the gland a much more irregular appearance. In both cases the surface of the body is uneven owing to the presence of globular swellings; whilst the whole body represents an acinous gland, each of the globules being a distinct acinus.

Before giving a description of the microscopic structure of the gland in *Lepas* I will describe its structure in *Scalpellum*. My best preparations are from *Scalpellum parallelogramma*, Hoek. In this species the gland is relatively small, having a length of little more than one millimetre. It is pyriform; at the narrow extremity it communicates with the interior of the stomach by means of a very narrow duct; at the other extremity its body is rather blunt and rounded. The greatest transverse diameter of the gland in

one of my series of sections measured 0·6 mm. In another series, however, it was more oval and measured 0·9 by 0·5 mm. The gland is not situated near the cardia but at a considerable distance, about half-way between the cardia and the dorsal surface of the body. The gland is a true tubular one; its wall consists of a single layer of cells only. The shape of these cells may be seen in Pl. VI. figs. 4 and 5. Each cell is cylindrical or rather conical, its base always being greater than the other extremity, which is directed towards the interior of the gland. The bases of the different cells are parallel to the nearly smooth outer surface of the gland; the other extremities of the cells, however, are as a rule not flat but convex, or even protuberant towards the interior of the canal which runs through the gland. In thin sections the outer surface of the gland is marked by a double line; the outer one is here and there distinctly sinuous, and between the two lines small nuclei are visible, which are rather flat; they are placed in the cavities between the inner and the outer margin. There can be no doubt that in this way a rudimentary *membrana propria* is formed. The connective tissue surrounding the glands has smaller meshes and is very rich in nuclei.

The dimensions of the glandular cells are about 0·1 mm. in length and 0·03 mm. in breadth. Each cell has granular plasmatic contents and a very large oval nucleus. In preparations stained with aluminium carminate the body of the cell as well as the nucleus has taken up the colour. The first is beautifully lilac-coloured, the latter darkly violet. Each nucleus is coarsely granulated and measures 0·036 by 0·02 mm. It contains a smooth and brilliant nucleolus of 0·009 mm. in diameter. In each nucleus the nucleolus is situated in the centre of a clear space, which, as a rule, is placed towards that side of the nucleus which is directed towards the internal surface of the gland. The clear space—which gives the impression of a clear vesicle with fluid, but which has no distinct contour of its own—is on one side separated from the surface of the nucleus only by a very narrow layer of the granular substance which fills the nucleus. The nucleus has a distinct external contour.

All the cells are built after the same type; but there are very characteristic differences between the cells of two different specimens of *Scalpellum parallelogramma*. In the first place there is a very marked difference in size; the length is nearly the same (0·09 mm.); the breadth, however, measures only 0·013 mm. and the nuclei are not, as in the first specimen which I investigated, placed close to the internal surface of the glandular cells, but beyond the middle: they are nearer to the external than to the internal surface. The structure of the nuclei is the same; they are more elongate and slightly pointed towards the outer extremity.

In a series of sections through the cephalic part of the body of *Scalpellum nymphocola*, these glands which I propose to call "pancreatic glands" are also represented. In this species the form of the gland is the same as in *Scalpellum parallelogramma*, the

transverse sections are circular or nearly so. The nuclei of the cells of the gland are all situated at the periphery close to the membrana propria which envelops the body of the gland.

The structure of the gland in *Lepas* will now be easily understood. Let the wall of the gland in *Scalpellum* develop excrescences, so that the interior of each excrescence communicates with the interior of the original or main part of the gland and the tubular gland will have changed into an acinous one. The excrescences have as a rule the shape of globules, but they may also be elongated so as to form finger-shaped appendages. When the gland is divided by transverse and parallel sections in a series of preparations the shape and size of the cells are by no means so uniform as in the case of *Scalpellum.* This, of course, is partly in consequence of the sections not always cutting the cells in the same direction, though parallel. In some of the sections the cells are cylindrical, having a length of 0·1 mm. and a breadth of 0·026 mm. If these same cells had been cut transversely to their longest axis, their length would have appeared much shorter. The size of the oval nuclei is 0·016 mm. In the more tubular parts of the gland the cells are not so high and their walls not so parallel; in the sections, therefore, they are almost triangular or flattened quadrangularly; between them I observed here and there larger cells with very capacious nuclei. I measured one of the cells, the length of which was 0·13, whereas its breadth was 0·9 mm. It was furnished with a nucleus 0·05 mm. in diameter The only difference which I could make out between the different cells of each gland was, however, in size; in regard to their staining with aluminium carminate, I must point out a very striking correspondence of these cells to those of the cement-apparatus of the peduncle, viz., the body of the cells is always beautifully lilac-coloured, the nuclei appearing dark violet. The latter are remarkable, in the same way also as those of the cement-glands, since coarse granules and even fibres fill their interior. A distinct membrana propria surrounds the body of the gland in *Lepas* as well as in *Scalpellum.*

The gland communicates with the interior of the stomach by means of a narrow duct which opens close to the cardia in an interspace between two of the so-called hepatic excrescences.

As to the function of these glands a few words may suffice. That they are not true salivary glands needs no further proof. At the same time it can hardly be doubted that their function is that of a digestive organ which pours its secretion into the alimentary canal. Whereas the recent interesting researches of Max Weber[1] have cast light upon the structure and function of the digestive glands (Verdauungsdrüsen) of the higher Crustacea (*Isopoda, Amphipoda, Decapoda*), we are still almost entirely ignorant of their occurrence, functions, structure, &c., in the different orders of Entomostraca. The supposition of Claus, that the name of liver in invertebrate animals has often been used

[1] Max Weber, Ueber den Bau u. die Thätigkeit der sog. Leber der Crustaceen, *Arch. f. Mikr. Anat.*, Bd. xvii. 1879.

where in reality a pancreatic or a chyle-producing gland should be spoken of, has proved to be very important. Weber, however, tries to demonstrate that in the Crustaceans which he studied, the digestive glands are built up of two kinds of glandular cells, and therefore are at the same time liver and pancreas, both modified so as to be accommodated to the organisation of the Crustacean body. Now no doubt is left that the glands of the Cirripedia are built up of *one* kind of cells only, and I think we can safely admit that these belong rather to the pancreatic than to the hepatic type. Whether the excrescences of the wall of the stomach (which are very strongly developed in *Lepas* and which are coated in the interior by a cylindrical epithelium with very small cells,[1] the nuclei of which are almost entirely hidden by a dark-brownish pigment) represent a kind of liver, I cannot undertake to say. It is indeed a curious fact—one, however, observed by Darwin thirty years ago—that these excrescences are large and well developed in some genera (*Lepas, Conchoderma*), and almost totally wanting in others (*Scalpellum*).

[1] The height of these cells is 0·03 mm., their breadth only 0·006 mm.

V. THE EYE OF LEPAS.

I believe Leidy was the first who observed in an adult Cirriped an organ of vision.[1] In *Balanus* there are, according to him (and Darwin has confirmed the correctness of his observation), two small eyes which stand apart from each other laterally and, owing to this discovery of the American naturalist, Darwin[2] was led to look for them in Lepadidæ. In *Lepas fascicularis* he found an elongated almost black eye composed of two eyes united together. The eye is innervated by two nerve-chords which extend from the front of the two supracœsophageal ganglia, and which before reaching the eye run into two small, perfectly distinct, oval ganglia. From the opposite ends of these two ganglia smaller nerves run, and, bending in at right angles, enter the elongated eye beyond the middle.

I do not think that any description of this organ has been published since Darwin's. I made preparations of it in *Lepas anatifera* and in *Lepas fascicularis*. The place it occupies in the first species may be seen on Plate VI. figs. 7 and 8. On removing the ligament between the two scuta as well as the muscles which are here placed between this ligament and the widened stomach, the surface of the latter with its black (hepatic ?) excrescences and the white pancreatic glands appear. At a distance of about 6 mm. from the supracœsophageal ganglion in an adult *Lepas anatifera*, a small oval black spot is seen attached by means of connective tissue to the surface of the stomach. This is the eye. Morphologically it represents the small pigment spot which, in the Cypris-larva (Pl. II. fig. 2, *e*), is attached to the upper surface of the supracœsophageal ganglion, and which is the remainder of the simple eye of the Nauplius-larva. In an adult *Lepas anatifera* it measures 0·25 mm. only in length, its breadth being not quite 0·15 mm. I believe its function to be of no consequence, in *Lepas* at least, for I do not understand how a ray of light can ever reach it, but the little organ beautifully illustrates the persistence of an old larval structure.

Most curious, however, is the fact that this rudimentary organ is indeed furnished with a kind of special ganglia (Pl. VI. fig. 9). Between the two broad (antennal) peduncular nerves, four thinner ones separate from the supracœsophageal ganglion. Their thickness is not quite the same ; the two outer ones are slightly stronger than the other two which lie very close to one another, almost exactly midway between the two other nerves. These four nerves can be traced up to a very short distance (about 0·6 mm.) from the small eye. Here the two stronger nerves of the four bend slightly outwards so as to approach a little more nearly to the peduncular nerves and show a distinct swelling, in the interior of which two elongate ganglionic cells are to be observed. I

[1] Leidy, *Proc. Acad. Nat. Sci., Philad.*, No. 1, vol. iv., January 1848.

[2] Darwin, Lepadidæ, 1851, p. 49.

think they can safely be described as bipolar, for their body can be followed up as a very pale process in the direction of the supraœsophageal ganglion as well as in the direction of the eye. In both directions these processes are placed, like the ganglionic cell itself, quite in the interior of the nerve. Close to the eye the nerve shows a second swelling which contains also a distinct ganglionic cell, and it is by this swelling that the nerve is laterally attached to the eye. Each of the two other slightly thinner nerves, which run between the two stronger ones, has also a swelling at about the same distance from the eye. The two nerves unite together where this swelling is thickest and where each contains a ganglionic cell; they then part again and separately run towards the eye, which they reach at its frontal extremity, *i.e.* that extremity which is directed towards the supra-œsophageal ganglion. I have not been able to study the way in which the nerves enter or are attached to the pigment spot. Round about the spot a network of fibres of greater or less capacity can easily be made out; yet it is extremely difficult, not to say impossible, to ascertain with certainty the nature of these fibres. Some of them are no doubt nerve-fibres, while others belong doubtless to the connective tissue.

The way in which the ganglionic cells are placed in the interior of the nerves slightly resembles what Leydig observed in the case of the sympathetic nerve-fibres of insects. He observed [1] (in *Bombus terrestris*) in single fibres of the so-called sympathetic nerves, a nucleus here and there with a granular mass surrounding it, forming a kind of bipolar ganglionic cell "in der Anlage."

Neither in *Lepas anatifera* nor in *Lepas fascicularis* could I distinguish the two little lenses which Darwin says he has observed. Nor do I think that this is owing to any fault in my observation. Darwin may have observed living, or at least fresh, animals, and the lenses may have disappeared under the influence of the alcohol. But I think it is more probable that Darwin, who used only a feeble magnifying power, has mistaken the ganglionic cells for lenses. What he calls the two small perfectly distinct oval ganglia, are probably the swellings of the optic nerves which in *Lepas anatifera* contain two distinct ganglionic cells.

As regards the sessile Cirripedia, and especially different species of *Balanus*, the experiments of different naturalists have shown that they are sensible to a difference between light and shadow. I do not know whether similar experiments have ever been made on pedunculated Cirripedia. Should they give the same result, and I think they very probably would, even then I should hesitate to consider the rudimentary simple eye placed on the external surface of the stomach as the organ of this function.

[1] Leydig, F., Bau des thierischen Körpers, Tübingen, 1864, p. 205.

VI. THE FEMALE GENITAL APPARATUS.

According to Darwin, the female genital apparatus consists of the true ovaria, or glandular bodies seated on each side, not far from the basal edge of the labrum; the main or unbranched ovarian ducts; and the ovarian branching tubes and cœca. The latter in the pedunculated Cirripedia are placed high up in the peduncle, and in all sessile Cirripedia lie between the calcareous or membranous basis and the inner basal lining of the sack. After the most careful and repeated examination of various Lepadidæ and Balanidæ, Darwin became convinced that there were no oviducts; he therefore supposed that the ova were brought to the surface by the formation of a new membrane round the sack underneath them, and by the subsequent exuviation of the old membrane. This supposition of Darwin's has proved to be erroneous. What Darwin called the main or unbranched ovarian duct is in reality the oviduct; it does not run up to the glandular bodies (which I have described in one of the foregoing chapters), but it passes at some distance beneath them (Pl. VI. figs. 7 and 8); it describes a curve and then enters the basal egment of the first cirrus, at the foot of which it opens.[1] Krohn was the first to describe the female genital apparatus accurately; Kossmann, though in the main agreeing with Krohn, differs from him with regard to the significance of the little shoe-shaped sack which is placed in a swelling of the oviduct near its opening. I studied the female genital apparatus in *Lepas*, *Scalpellum vulgare* and *Scalpellum regium*, in *Conchoderma virgatum* and in *Balanus*. In all essential points the results of my researches tend to confirm those of my predecessors; in detail I think I am able to add to our knowledge.

From the existence of two oviducts we may conclude that there are also two ovaries present. In the full-grown animals their numerous and strongly ramified cœca are united so intimately that they seem to form a single mass only. The cœca of the right side, however, communicate with the right oviduct, the others with that on the left.

A study of the way in which the ova are formed has given the following results. The oviduct itself is lined by a very distinct and well-developed epithelium; where the limits of the cells are not distinct, which may be due to the condition of the material at command, the nuclei are placed so regularly along the wall that even the dimensions of the epithelial cells can still be made out. Where the oviduct passes over into a cœcum of the ovary, the epithelium of the wall is no longer so distinct, and in its place nuclei are seen rather irregularly along the wall; of the true body of the cell there are only traces here and there. The ovigerms or future ovarian eggs are seen in the interior along this wall. When the ovary is mature or nearly so, we observe in the first place the large ovarian eggs, each having a nucleus with a sparkling nucleolus (Pl. VI. fig. 2) about

[1] Zool. Chall. Exp., pt. xxv. p. 12, pl. i. fig. 2.

the centre of the egg, and in the second place, rounded groups of very small ovigerms, forming together what the Germans call the "Keimlager." One or two of these ovigerms are often slightly larger than the rest, and these will be the first to develop into ovarian eggs after those which are already mature are evacuated.

In a ripe or nearly ripe ovarian egg of *Scalpellum vulgare* which had a diameter of 0·3 mm., a nucleus of 0·036 mm. was present, having a nucleolus of 0·009 mm. The nuclei of the cells placed along the wall of the ovary are oval and measure about 0·01 by 0·005 mm.; the small ovigerms are nearly circular and have a diameter of about 0·013 mm. Their nuclei, of course, are a great deal smaller than those of the ripe ovarian eggs. One of the ovigerms was considerably larger; it was rounded oval, its diameters being 0·03 and 0·023 mm.; its nucleus was about 0·012 mm. A ripe ovarian egg of *Scalpellum vulgare* is filled with a coarsely granulated vitelline mass (Pl. VI. figs. 1*A*, 2*x*). Between the larger granules, which in the microscopical preparations appear like vesicles, a much more delicately granulated mass of plasma is here and there visible; sometimes a layer of this is placed in the centre round the nucleus. The wall of the ovarian egg seems to be a very thin and structureless membrane, and neither in the case of *Scalpellum*, nor of any of the other genera observed, was a follicular epithelium present. The mature ovarian eggs of *Scalpellum regium* are about 0·6 mm. in diameter. They are very coarsely granulated; they do not quite fill the interior of the ovarian cœca, but between them, and also between each egg and the wall of the cœcum, a layer of a much more delicately granulated mass of plasma is visible (Pl. VI. fig. 3). Here the ovigerms form groups of little cells, the dimensions of which nearly correspond to those of *Scalpellum vulgare*. In one of these groups I counted about 20 of these ovigerms. Here again one of these ovigerms was developed into a young ovarian egg. The wall of the cœca shows the same cellular elements as in *Scalpellum vulgare*; its outer surface is formed by a distinct membrana propria, which may be composed of stronger fibres of connective tissue, but which often looked as if composed of circular muscular fibres. The wall of the oviducts, however, did not show the same stronger outer wall; it is composed of a distinct epithelium and a very narrow or thin membrana propria.

Whereas in *Scalpellum vulgare* each oviduct gives off a cœcum only once, and this cœcum, which starts from the oviduct at the superior extremity of the peduncle, divides again and again, the oviduct in *Scalpellum regium* penetrates into the interior of the peduncle for about one-third of its whole length. In different places each oviduct in this species gives off cœca, and these form together so voluminous a mass that the peduncle is filled with it up to its inferior extremity.

The oviduct of *Scalpellum vulgare* appears in a transverse section as an exceedingly narrow slit, and 0·2 mm. in length. The oviduct of *Scalpellum regium* (Pl. V. figs. 8 and 9), in a transverse section shows an irregularly folded wall; its largest

diameter is about 0·55 mm., its smallest 0·15 mm. I calculated that for *Scalpellum regium* the surface of the lumen of the oviduct was about 0·09 square millimetres, whereas a section of one of the nearly ripe ovarian eggs was not less than 0·28 square millimetres. Therefore, it is either necessary that the walls of the oviducts be very elastic, or that the eggs pass through the oviduct when it is much distended. Perhaps both circumstances favour the passage of the ova.

The number of eggs laid by *Lepas* is immensely larger than by *Scalpellum*. In some of the species of the latter genus it is not even a hundred; in *Lepas anatifera* it amounts, on the contrary, to many thousands and tens of thousands. In accordance therewith, the eggs of *Lepas* are very small; I measured eggs from an egg mass of this species, and their length was only 0·24 mm. The cœca which form the ovary are very narrow and elongate, and contain rows of numerous and relatively small eggs. The ovarian egg when ripe is not so elongate as after its fecundation; I measured eggs in the oviduct, the length of which was only 0·14, their breadth being 0·1 mm. The nuclei of the eggs in the ovary are again nearly circular, and have a diameter of about 0·02 mm.; they may be seen as a rule in the centre of each ovarian egg, and contain a single very distinct nucleolus. In the cœca of younger specimens of this genus, the groups of ovigerms can be very distinctly made out. The number of ovigerms composing such a group in this genus, however, is much larger than in the genus *Scalpellum;* their dimensions do not show any considerable difference.

In *Conchoderma virgatum* the form of the cœca corresponds to that in *Lepas*. The eggs are numerous and small. I do not think it of much use to give any details as to their dimensions.

When comparing young ovarian cœca, such as are observed in the peduncles of younger specimens, with those which are gorged with numerous and larger eggs, one feels convinced that a considerable increase in bulk has taken place. This can only have been brought about by a regular and abundant supply of food. Yet it is not so very easy to understand in what way the nourishment of the peduncle is brought about. The only way is, of course, that the blood—or the fluid which in Cirripedia acts as blood—passes through the narrow band which in the pedunculated Cirripedia runs from the capitulum to the peduncle, at the rostral side near the place where the two scuta meet with their occludent margins. The two strong peduncular (antennal) nerves and the oviducts pass through this narrow commissure; but so does also a rather wide cylindrical tube which has no distinct wall of its own, and therefore is lined only by connective tissue, and which here represents the body cavity. In those cases in which I found the ovarian eggs ripe or nearly ripe, I always found this canal totally filled up by a delicately granulated mass, which much resembled blood plasma. I therefore think it highly probable that by means of this elongate canal a regular nourishment of the peduncle and the organs placed in it is carried on. In *Scalpellum parallelogramma* I have been successful in tracing

this canal, or cylindrical cavity, to within the body of the animal. When a transverse section of the body is made near the mouth, the alimentary canal in the middle of its dorsal surface is found attached to the wall of the body by means of a rather strong band of connective tissue. Towards the hinder extremity of the body this band grows broader still, and then it appears to be perforated by a central cavity. Towards the anterior end of the body the band grows narrower, yet it may be followed up in all transverse parallel sections, as long as these contain a section of the stomach. Those sections which pass through that part of the body contained between the stomach and that stripe of the mantle which unites the two scuta, only show the band of connective tissue as a loose band attached only on one side, viz., on the dorsal internal surface of the body wall. The two large cavities which were separated from one another by means of this band, are now united. An excrescence of this cavity penetrates this part of the body in a direction vertical to the original dorsal surface, and this part of the body cavity has one of the two sections of the oviducts on each side. It advances considerably towards the original ventral surface of the body and now meets the two sections of the oviducts on the dorsal aspect; after having described a curve it runs longitudinally close to the rostral surface of the narrow part between the two scuta. The two oviducts are now on that side of the cavity which is directed towards the interior of the mantle-cavity, and in the same place they remain visible in the superior part of the peduncle.

The course of the oviducts through the true body of the Cirripedia can be followed up by making a dissection of it by the aid of needles. To make out its position with regard to the place occupied by the other organs a series of sections serves the purpose still better. In *Scalpellum* transverse sections through the cephalic part of the body show the oviducts on both sides about midway between the intestinal tract and the wall of the body (Pl. VI. fig. 4). It is surrounded on all sides by the connective tissue, and as a rule one of the larger cavities of the connective tissue is separated from the duct only by a very narrow strip of the tissue. In *Scalpellum* as well as in *Lepas* and *Balanus* (the three genera in which the course of the oviducts has been investigated), the oviducts pass beyond the first pair of cirri. They then run upwards, *i.e.*, towards the ventral surface of the body, and bending outwards, *i.e.*, towards the lateral surface of the body, and forwards, they enter what Darwin considers the basal articulation of the first cirrus. In some of the genera (*e.g.*, *Lepas*, *Alepas*), this swelling belongs doubtless to the first cirrus; from analogy we may safely conclude that it belongs also to that pair of extremities in those cases in which (as in *Scalpellum*) no distinct relation to it can be made out. The oviduct enters this articulation at a considerable distance upwards from its base; it now describes a curve for the last time and leads into the curious sack which Darwin considered an acoustic organ, and which opens by means of a transverse slitlike orifice at the proximal part of the basal articulation.

The structure of the wall of the oviduct may be briefly described as epithelial;

the limits of the cells are never very distinct, and their height is inconsiderable; the contents of the cell are a nucleus about 0·005 mm. in diameter and quite clear protoplasm. A very thin membrana propria covers the outer surface of the oviduct.

The way in which the oviduct corresponds with the sack in the basal articulation of the first cirrus in *Scalpellum* is different from *Lepas*. In *Scalpellum vulgare* (Pl. VI. fig. 10), and *Scalpellum parallelogramma*, the oviduct, once arrived in the basal articulation, expands so as to form a kind of funnel, which with its wide opening embraces a large portion of the curious sack which opens at the base of the swelling. The wall of this funnel closely resembles that of the oviduct. In some of my preparations the funnel is placed exactly opposite to the genital opening, in others it is attached to the sack in a more oblique direction. The curious sack, in *Scalpellum*, communicates with the genital opening by means of a long duct, the length of which equals and sometimes even surpasses that of the sack itself. At the other extremity the sack is open also and its wall round about the opening turned outward, the opening of the funnel closing exactly on the margin of the part which is turned out. In one of my series of preparations of *Scalpellum vulgare* the funnel-shaped widening of the oviduct is in close relation with a bag of connective tissue surrounding the whole sack, so that it may be traced up to where the sack goes over into the duct; at first it was my opinion that the eggs passing through the oviduct and the funnel arrived in this bag and then passed into the duct by a lateral opening situated beneath the sack, without entering the curious sack at all; but I failed to make out the existence of this opening, and since I afterwards observed the direct transition of the oviduct into the curious sack in the genus *Lepas* (Pl. VI. fig. 11), I have given up this supposition, which I must confess was rather hazardous.

The structure of the cells which compose the wall of the curious sack is that of a high cylindrical epithelium. In *Scalpellum vulgare* their dimensions are 0·02 by 0·006 mm.; each cell has a very distinct oval nucleus which, in the full-grown specimens, measures 0·006 by 0·005 mm., and which is seated very close to the free extremity of the cell. The outer surface of the sack is lined by a membrana propria with very flat nuclei. The shape of the sack in *Scalpellum* is that of a pear, the part which communicates with the duct being as a rule narrower than the other extremity. In *Scalpellum vulgare* the duct shows a small swelling near the place where it communicates with the sack, and the length of the duct is exactly equal to that of the curious sack. The wall of the duct has the same structure as the outer wall of the body, as an inflected part of which it must be necessarily considered. The limits of the cells which compose it are not distinct, its nuclei are relatively oval and large, their longest diameter being 0·009 mm. The surface of the duct is covered by a thin chitinous cuticle.

In none of the species of the genus *Scalpellum* in which I investigated this curious sack did I find it empty (*Scalpellum vulgare*, *Scalpellum parallelogramma*, *Scalpellum nymphocola*, *Scalpellum regium*, and *Scalpellum balanoides* have been investigated by means of

sections). I always observed in its interior the "flattened sack of singular shape" which Darwin called the acoustic sack. As long as I knew this sack only from preparations of *Lepas anatifera*, young specimens of which I cut into series of sections some years ago, I really considered it with Darwin and Krohn[1] as a sack. Guided by this opinion, I wrote the passage on page 12 of my Report on the Challenger Cirripedia, in which I gave it as my opinion that the interpretation of Krohn was more in accordance with the facts than Kossmann's; for Kossmann called the sack a "Klumpen," *i.e.*, an irregularly-shaped mass, which is sometimes quite solid, sometimes is only furnished with very irregular cavities. A glance at Pl. VI. fig. 10 will easily convince the reader that Kossmann's suggestion is now indeed mine also; the curious body looks like a compact mass, being composed of smooth layers which have probably been more or less parallel to the wall of the sack, and a granular substance binding these layers together. All the cells bordering the sack, as also those forming the part which is turned outward, participate in the act of secreting the fluid, which hardens to compose the compact body. Hence it is suspended as by two short arms in the opening which leads from the funnel of the oviduct into the curious sack. The compact body must be evacuated before the eggs can pass through the curious sack and the narrow duct, and I think that this is done by the retraction of the margin of the opening which leads from the funnel into the sack. In one of my series of preparations of *Scalpellum vulgare* the opening of the sack is as wide as that of the funnel; the arms of the compact body form a transverse partition between funnel and sack, the remaining part of the compact mass being suspended in the middle of this partition. Regarding the structure of this same apparatus in other genera of Cirripedia I have little to add. In *Lepas anatifera* and *Lepas hillii* the structure of the oviduct is the same as in *Scalpellum*. The funnel at the end of the oviduct where it communicates with the sack seems to be wanting; in a very complete series of preparations of *Lepas hillii* the oviduct can be followed up to where it communicates with the sack. Its structure is very markedly different from that of the sack, so that the place where the one ends and the other begins can easily be seen (Pl. VI. fig. 11). It widens only very inconsiderably to meet the opening of the sack. The wall of the sack is composed of very high and narrow cells (0·05 mm. high and 0·003 mm. wide), having an oval nucleus about half way up. The length of the sack itself in *Lepas hillii* is about 0·8 mm. In *Lepas anatifera* it is a great deal more; in a specimen, the capitulum of which measured 38 mm., the greatest diameter of the sack was 3 mm., the shoe-shaped mass in its interior measuring about 2 mm. I observed the curious sack at the end of the oviduct also in *Balanus corolliformis*, Hoek, and in *Balanus tintinnabulum*, Linné. Its size in the first species is about 0·5 mm.; the way in which the oviduct communicates with the sack in this species is very like that in *Scalpellum*,—the oviduct is considerably swollen at the extremity which meets the sack.

[1] Krohn, *loc. cit.*, p. 361.

The sack of *Balanus tintinnabulum* was studied in transverse sections; its diameter was about 0·9 mm. I have been unable to investigate the way in which the oviduct communicates with it.

If Kossmann's explanation as to the presence of the irregular mass in the interior of the curious sack at the end of the oviduct be right (and I have no sufficient ground to doubt its correctness), the function of the cells which form the wall of the sack is to produce a viscous fluid which envelops the eggs. The thick mass which sometimes, and even very often or *as a rule,* is found in the interior of the sack is formed because the secretion continues incessantly, even when no eggs pass through the oviduct. The quantity of this viscous fluid which is secreted by these cells must indeed be rather large; for when a *Lepas* is furnished with ovigerous lamellæ and the interior of its sacks studied, large masses of the secreted substance are present. This must necessarily have been formed after the eggs passed through it, and cannot have been very long before, as in the Cirripedia the evolution of the eggs in general does not take long. The very regular shape of the mass in some genera, as *e.g.* in *Lepas,* where it is shoe-shaped and has a very smooth surface, must be ascribed to its being modelled, at least in part, after the internal surface of the sack; it remains, however, in my eyes a curious fact which, perhaps, has an analogy in the presence of a chitinous bag within the stomach in this same group of Cirripedia. I observed it in the stomach of all the Cirripedia of which I prepared transverse sections; according to Darwin it is a model of the stomach, filled with excrement and expelled by the rectum entirely in a single piece, as he observed in some living specimens of *Balanus balanoides.*

To understand the physiological meaning of the apparatus at the end of the oviducts, a second difficulty arises from the circumstance that we do not know the place where, and the way in which, the eggs are fecundated. If Kossmann's supposition be correct, the eggs are evacuated after being united together by means of the fluid secreted by the cells of the curious sack. These eggs, however, are ovarian, not yet fecundated eggs! I think it is difficult to understand how they are fecundated after they are united together by a fluid viscous glue. Of course, the only way of investigating successfully physiological questions of this kind is to study fresh and living material. But this study can only give trustworthy results when the anatomical structure is sufficiently well known. I think I have contributed to a more accurate knowledge of the anatomical structure.

I will not take leave of this subject without pointing out the great probability that the apparatus at the end of the oviduct morphologically represents a second segmental organ. Krohn[1] has already shown that, of all Crustaceans, the female genital openings are placed nearest to the cephalic part of the body in the Cirripedia; and even at present, though our knowledge of Crustaceans has been considerably increased since the year 1859, it is still true that they are the only Crustaceans which show this

[1] *Loc. cit.*, p. 360, note at the foot of the page.

peculiarity in their structure. The curious animal which Prof. Lacaze-Duthiers has described as *Laura gerardiæ*, and which according to him belongs to a distinct group of abnormal Cirripedia, has the female genital openings also in the basal segment of the first pair of legs. The peculiar position of these openings in this group would, however, not be so strange, if it could be shown that the female genital apparatus in the case of Cirripedia made use of a segmental organ. Now, I think everybody, who will study preparations of the curious sack and the oviduct in relation to it, will be struck by the totally different structure (1) of the oviduct, (2) of the sack itself, and (3) of the canal or duct, short in *Lepas* and long in *Scalpellum*, at the end of which the genital opening is placed. To call the sack a widened part of the oviduct is not in accordance with the condition of these parts at the place where they are in communication with each other. Even in *Lepas*, where the communication is much more gradual than in *Scalpellum*, the place where the oviduct terminates and the sack commences is very distinct. Since the duct by the aid of which the sack opens is a true epiblastic product, and is lined by a thin chitinous cuticle, the sack, which is placed between it and the oviduct, probably represents the funnel of the original segmental organ. Of course, this suggestion is based on the occurrence of the other pair of segmental organs opening at the base of the second maxillæ described on p. 23 of this Report.[1] The first pair of segmental organs furnishes a direct communication of the body-cavity with the surrounding medium, the second serves for the evacuation of the female genital products. The cells of the funnel of the first pair, probably, have an excretory function; those of the second pair have a more special function,—that of producing a viscous fluid for uniting the eggs into egg masses.

I hope I shall soon be able to continue these investigations and if possible to enlarge them with the aid of fresh material.

[1] Zool. Chall. Exp. part xxv.

PLATE I.

PLATE I.

An. stands for	antennæ.		*mr.* stands for	retractor muscle of the thorax.	
c.gl.	,,	cement glands.	*o.*	,,	orifice of the sac.
f.	,,	muscular fibres.	*œ.*	,,	œsophagus.
gt.	,,	thoracic ganglion.	*r.*	,,	œsophageal ring.
gs.	,,	supraœsophageal ganglion.	*st.*	,,	stomach.
gl.	,,	gland of unknown nature.	*t.*	,,	testis.
l.	,,	thoracic appendages.	*vd.*	,,	vas deferens.
m.	,,	mouth.	*vs.*	,,	vesiculæ seminales.

Fig. 1. Male of *Scalpellum regium* (Wyv. Thoms.), Hoek; magnified 94 diameters.

Fig. 2. Nervous and alimentary systems of this male; magnified 275 diameters.

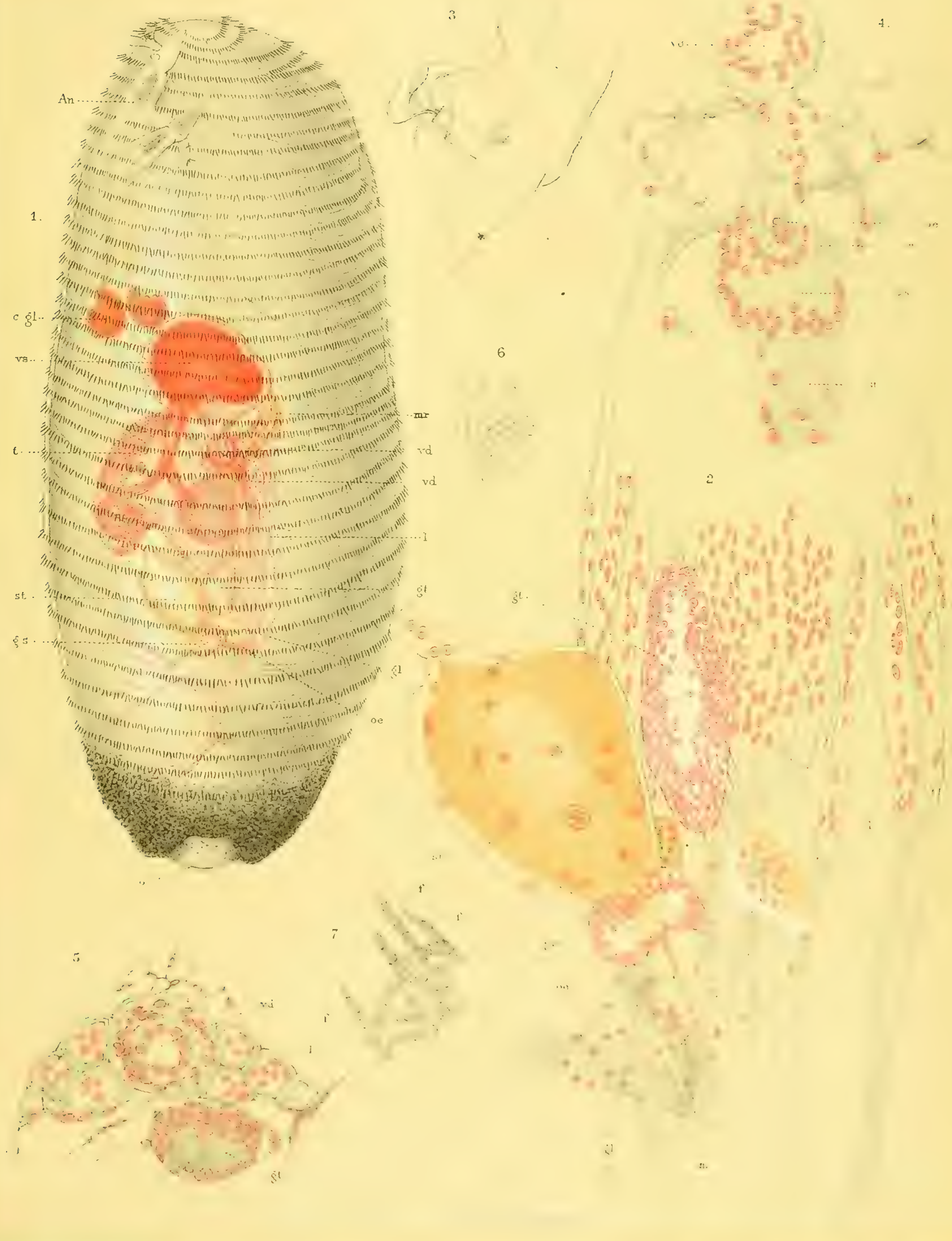
Fig. 3. Antenna of the male; magnified 275 diameters.

Fig. 4. Transverse section of the supraœsophageal ganglion where it is in relation with the œsophageal ring; magnified 275 diameters.

Fig. 5. Transverse section of the thoracic ganglion and the thorax with its appendages; magnified 275 diameters.

Fig. 6. Spermatozoa and spermatozoid mother-cells; magnified 575 diameters.

Fig. 7. Epithelium of the sac and muscular fibres in a young stage of development; magnified 275 diameters.



P. P. C. Hoek Del.

MALE OF SCALPELLUM REGIUM.

PLATE II.

PLATE II.

AM. stands for	adductor muscle.	*Int.* stands for	intestine.
An. ,,	antennæ.	*Inv.* ,,	invagination dividing the body into a capitulum and peduncle.
C. ,,	cœca attached to œsophagus.	*M.* ,,	mouth.
C I.–C VI.	thoracic appendages.	*Ma.* ,,	mantle.
CA. ,,	caudal appendage.	*Od.* ,,	ovarium with oviduct.
C.gl. ,,	cement glands.	*Œ.* ,,	œsophagus.
E. ,,	the large compound eye.	*Op.* ,,	orifice of the mantle.
e. ,,	the simple eye.	*Sh.* ,,	shell.
G I.–G VI.	thoracic ganglia.	*S* or *St.*	stomach.
GS. ,,	supraœsophageal ganglion.		
GT. ,,	thoracic ganglion.		

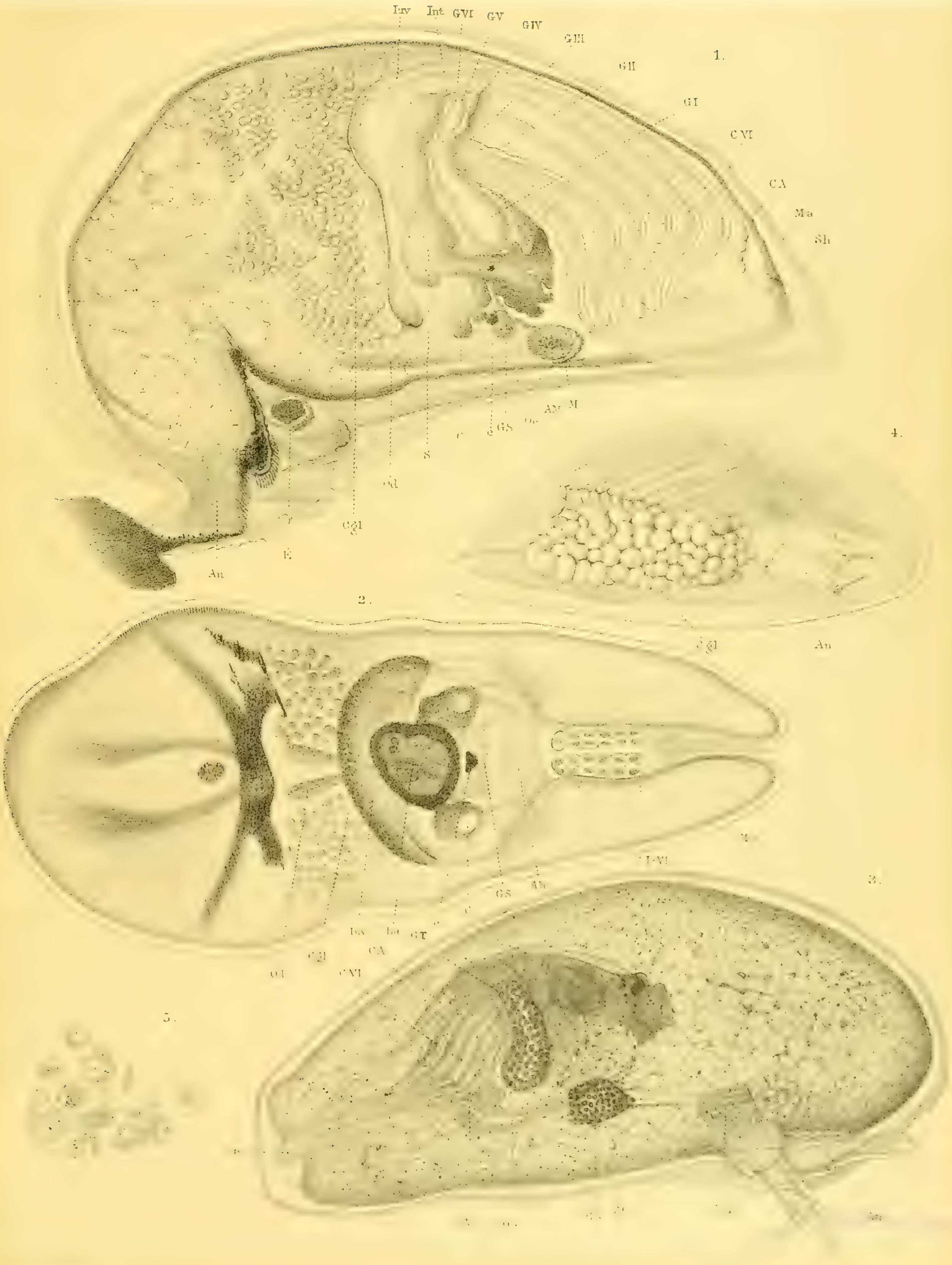
Fig. 1. Cypris-larva of *Lepas australis*, Darwin, sagittal section ; magnified 70 diameters.

Fig. 2. Same larva in a slightly older stage, longitudinal section ; magnified 70 diameters.

Fig. 3. Cypris-larva of *Scalpellum regium* (Wyv. Thoms.), Hoek, which is destined to develop into a male ; magnified 94 diameters.

Fig. 4. Cypris-larva of *Scalpellum triangulare*, Hoek, which is also destined to become a male ; magnified 94 diameters.

Fig. 5. Group of cement-cells with their ducts and pale yolk-elements of the Cypris-larva of *Lepas australis*, Darwin ; magnified 275 diameters.



P. P. C. Hoek Del.

A. J. Wendel Lith.

CYPRIS-LARVAE OF CIRRIPEDIA.

PLATE III.

PLATE III.

ca.	stands for	cavity in which thorax is lodged.
gs.	,,	supraœsophageal ganglion.
gt.	,,	thoracic ganglion.
l.	,,	thoracic appendages.
m.	,,	longitudinal muscles of body-wall.
mr.	,,	retractor muscle of the thorax.
o.	stands for	orifice of thoracic cavity.
st.	,,	stomach.
t.	,,	testis.
th.	,,	thorax.
vd.	,,	vas deferens.
vs.	,,	vesiculæ seminales.

Eleven sections out of a series of about eighty through the body of the male of *Scalpellum regium* (Wyv. Thoms.), Hoek.

Fig. 1. Transverse section near the capitular pole.

Fig. 2. Second section. The outer wall is covered by particles of mud; where it is taken away, the nuclei of the chitinogenous epithelium are distinctly visible.

Fig. 3. Third section. To the left the orifice is visible surrounded by a dense mass of cells of the chitinogenous epithelium; to the right the connective tissue is visible with its small nuclei and with the longitudinal muscles of the body-wall.

Fig. 4. One of the following sections, passing transversely through the cavity in which the thorax of the little body is lodged, and which opens outwards by means of the orifice in figs. 1 and 2.

Fig. 5. One of the following sections about the place where the vas deferens opens into the cavity of the foregoing figure.

Fig. 6. Section passing through one of the lobes into which the testis is divided at its capitular extremity, through the stomach, the supraœsophageal ganglion, the thoracic ganglion, the thorax with its central canal, the vas deferens, and the appendages.

Fig. 7. In this section both lobes of the testis are represented.

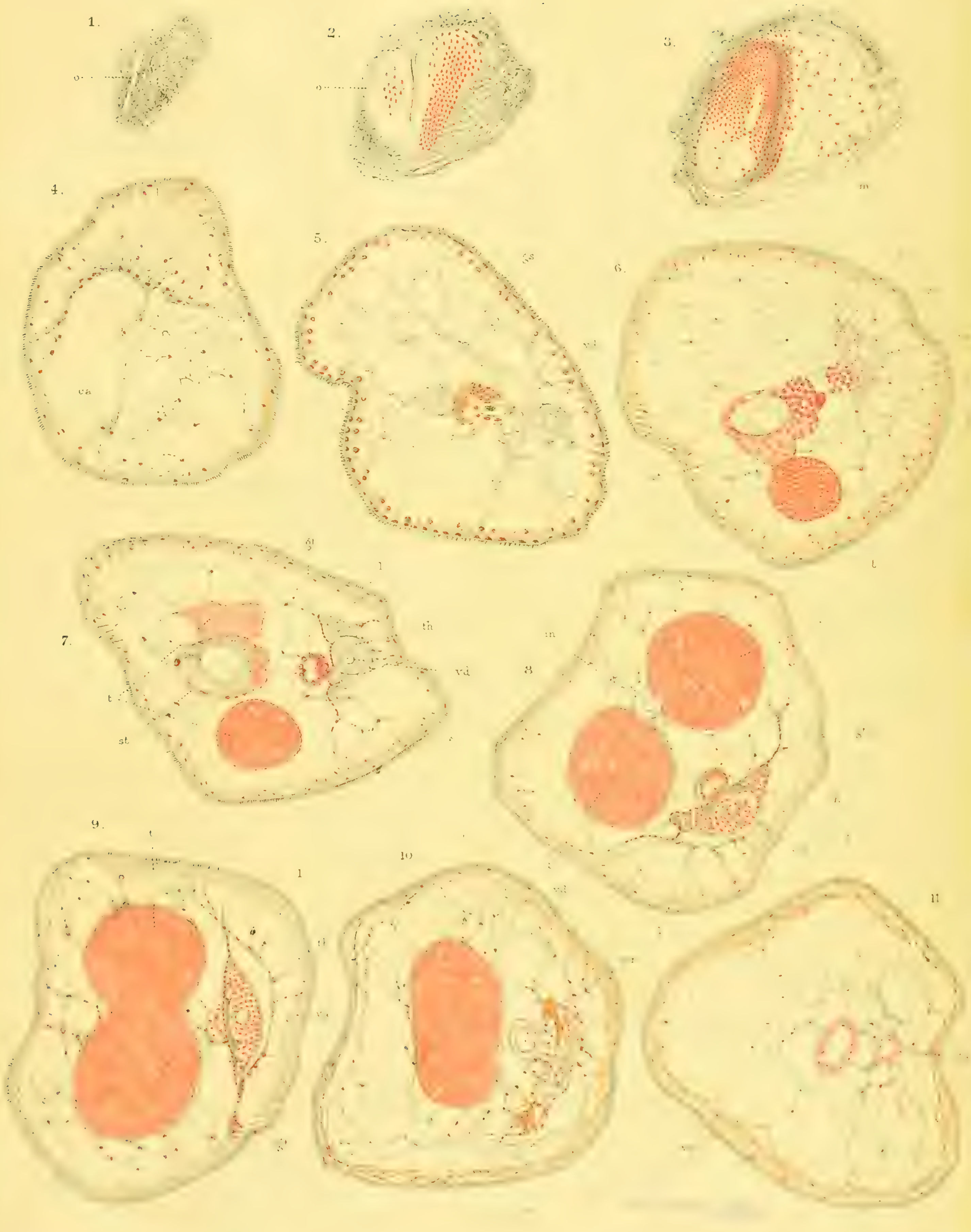
Fig. 8. Between the two sections of the testis the narrow blind sack of the stomach which represents the intestine is visible.

Fig. 9. The two lobes of the testis have united; the thoracic ganglion is only indistinctly represented.

Fig. 10. Section passing through the upper extremity of the thorax.

Fig. 11. Section passing through the vesicula seminalis and vas deferens before the latter enters into the thoracic part of the body.

All the figures are magnified 94 diameters.



P.P.C. Hoek Del.

A.J. Wendel Lith.

MALE OF SCALPELLUM REGIUM.

PLATE IV.

PLATE IV.

an. stands for anus.
c. ,, chitinous wall of the peduncle.
ca. ,, caudal appendages.
cf. ,, connective tissue fibres.
ct. ,, connective tissue nuclei.
cg. ,, cement glands.
g–g′–g″ ,, first and second thoracic ganglion.
g.a. ,, female genital aperture.
gl. ,, glands of unknown function.
gt. ,, thoracic ganglion.
i. ,, intestine.
mf. stands for muscular fibres.
n. ,, nuclei of the chitinogenous epithelium.
p. ,, penis.
s. or *st.* ,, stomach.
t. ,, testis.
th. ,, thorax.
vd. ,, vas deferens.
vs. ,, vesicula seminalis.
x. ,, widened portions of the oviducts near the genital aperture.
I.–VI. ,, first to sixth cirrus.

Figs. 1–7. Anatomy of the male of *Scalpellum regium* (Wyv. Thoms.), Hoek.

Fig. 1. Transverse section through a male of *Scalpellum regium*, which is in a young stage; stomach filled almost entirely with nutritive yolk.

Fig. 2. Section passing through the vesicula seminalis and a narrow portion of the testis.

Fig. 3. Section passing through a younger male at the level of the cement glands.

Figs. 1–3 magnified 94 diameters.

Fig. 4. Section of one of the cement glands; magnified 275 diameters.

Fig. 5. Section of the wall of a male; magnified 575 diameters.

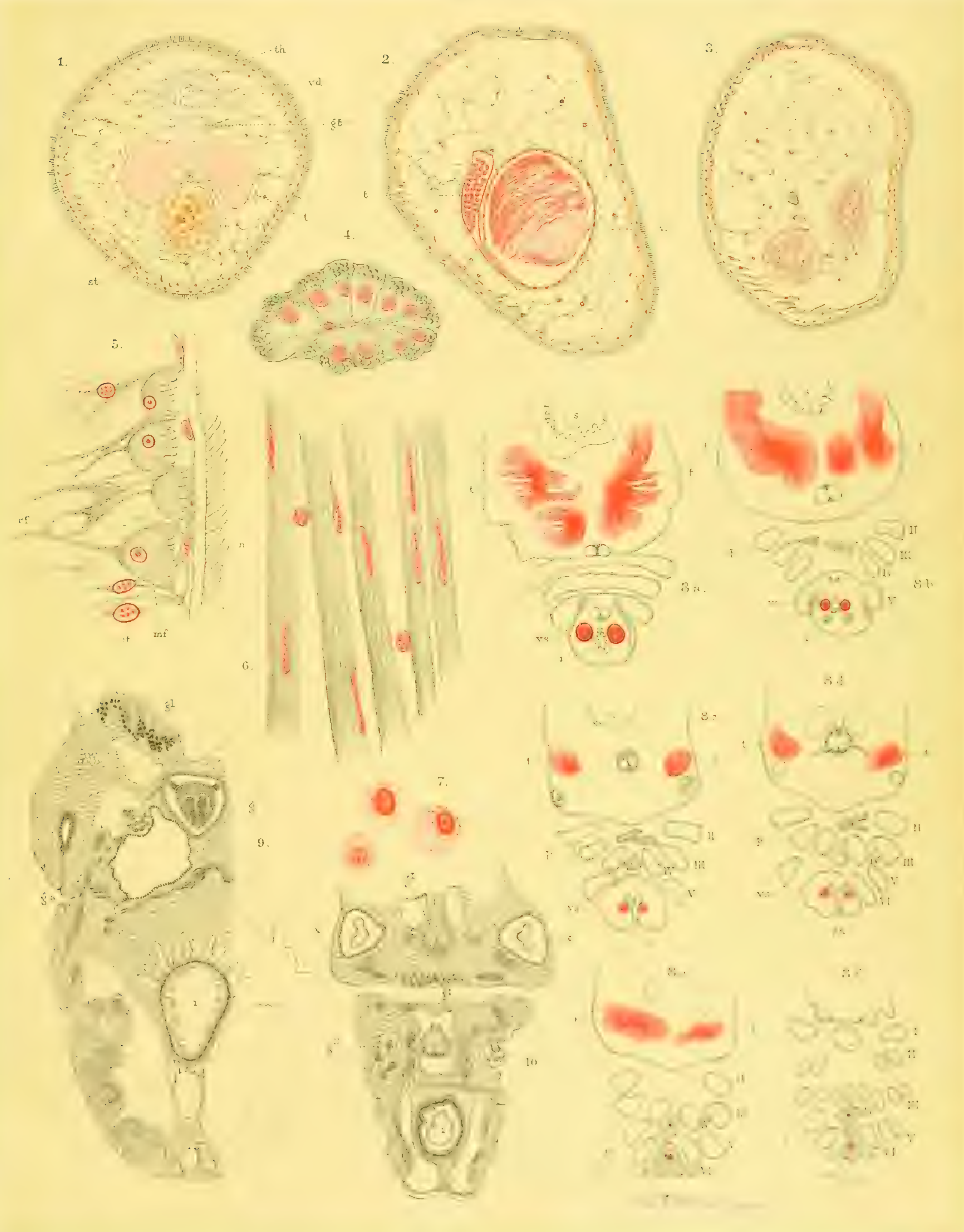
Fig. 6. Muscular fibres; magnified 575 diameters.

Fig. 7. Supposed blood-corpuscles; magnified 575 diameters.

Figs. 8*a*–8*f*. Six out of a series of transverse sections through the body of *Scalpellum calanoides*, Hoek; magnified 41 diameters.

Fig. 9. Part of a section through the body of *Scalpellum parallelogramma*, Hoek, at the base of the first pair of cirri; magnified 26 diameters.

Fig. 10. Part of a section through the body of *Scalpellum nymphocola*, Hoek; magnified 41 diameters.



P.P.C. Hoek Del. A. J. Wendel Lithogr.

1-7 MALE OF SC. REGIUM. 8 SC. BALANOIDES. 9 SC. PARALLELOGRAMMA. 10 SC. NYMPHOCOLA.

PLATE V.

PLATE V.

A. stands for	body-cavity.	
a.	,,	outer layer of (longitudinal) muscles.
B.	,,	band of connective tissue.
b.	,,	second layer of (circular) muscles.
C.	,,	organ of unknown function.
c.	,,	inner layer of (longitudinal) muscles.
C.gl.	,,	cement glands.
Ch.	,,	chitinous outer wall of peduncle.
D.	,,	main cement duct.
D′–D‴	,,	branches of the main cement duct.
d.	,,	initial cement ducts.
e. stands for	darkly pigmented epithelium.	
in.	,,	intestine.
M.	,,	outer maxilla.
m.	,,	muscle masses.
n.	,,	nerve cords.
O.	,,	ovarian cœca.
od.	,,	oviduct.
t.	,,	testis.
s.	,,	segmental organ.
Sd.	,,	segmental duct.
x.	,,	(elastic) fibres of the connective tissue.

Figs. 1–3. Segmental organ of *Scalpellum vulgare*, Leach.

Fig. 1. Transverse section of the body of *Scalpellum vulgare*, Leach, about the second pair of maxillæ; magnified 27 diameters. The band of connective tissue (B) contains cœca of the testis.

Fig. 2. Section of the segmental funnel; magnified 305 diameters.

Fig. 3. Section of the segmental organ; magnified 106 diameters.

Figs. 4, 5. Anatomy of the peduncle of *Lepas anatifera*, Linn.

Fig. 4. Transverse section near the upper extremity; magnified $8\frac{1}{2}$ diameters.

Fig. 5. Part of a section near the upper extremity; magnified 58 diameters.

Figs. 6, 7. Anatomy of the peduncle of *Scalpellum vulgare*, Leach.

Fig. 6. Part of a section at about 5 mm. from the upper extremity; magnified 33 diameters. The chitinous outer wall with the scales removed.

Fig. 6*. One of the cement glands; magnified 192 diameters.

Fig. 7. Part of a section near the lower extremity; magnified 33 diameters.

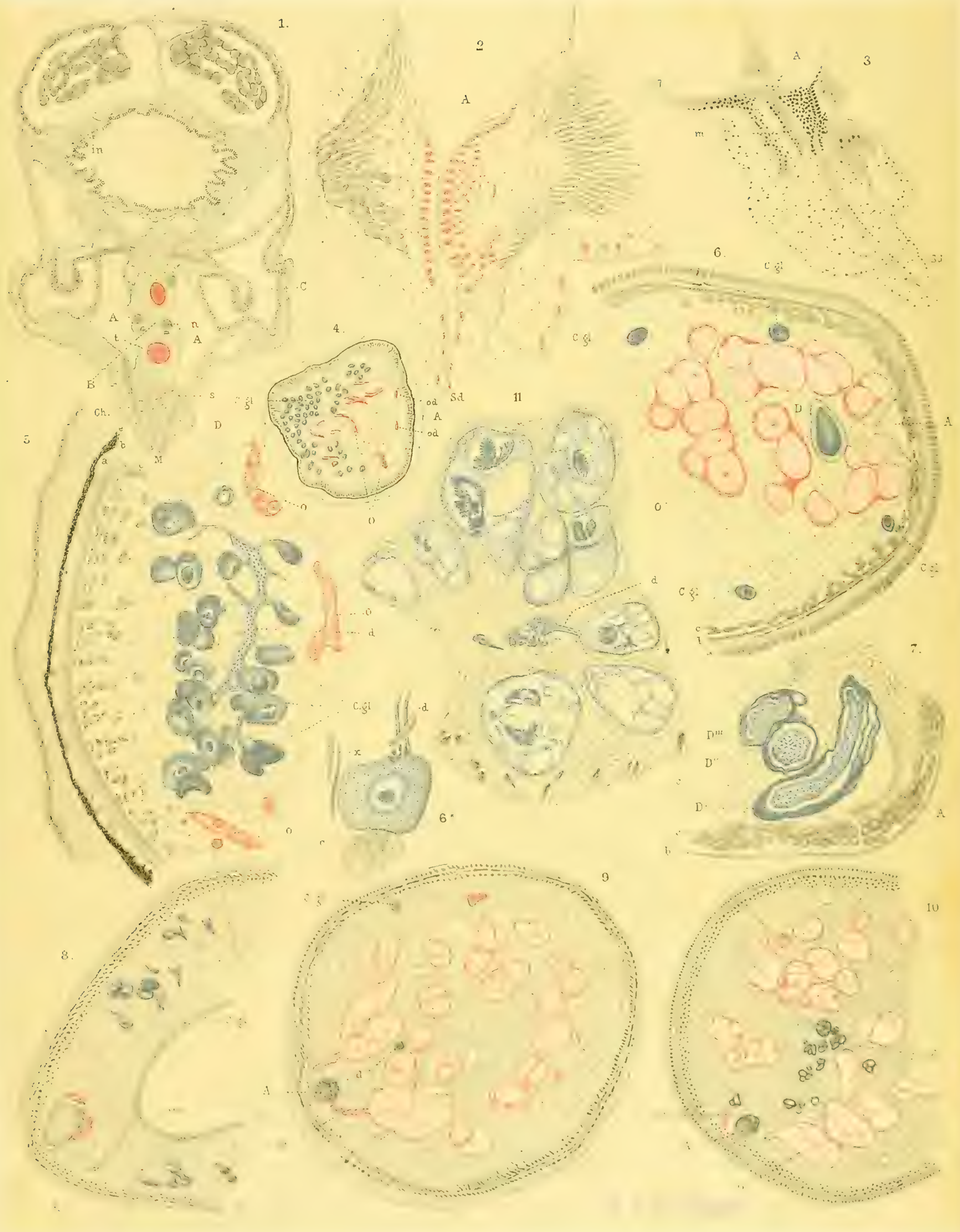
Figs. 8–11. Anatomy of the peduncle of *Scalpellum regium* (Wyv. Thoms.), Hoek. (The chitinous outer wall with the scales removed.)

Fig. 8. Part of a section near the upper extremity; magnified $8\frac{1}{2}$ diameters.

Fig. 9. Section at about 1 cm. from the upper extremity; magnified $8\frac{1}{2}$ diameters.

Fig. 10. Section about half the length of the peduncle; magnified $8\frac{1}{2}$ diameters.

Fig. 11. Group of cement glands in the upper extremity of the peduncle; magnified 58 diameters.



P. P. C. Hoek Del.

A. J. Wendel Lithogr.

1-3 SCALPELLUM VULGARE. 4-5 LEPAS ANATIFERA. 6-7 SC. VULGARE. 8-11 SC. REGIUM.

PLATE VI.

PLATE VI.

A. (in fig. 1) stands for matured ovum.
A. (in fig. 3) ,, body-cavity.
A. (in fig. 6) ,, musculus adductor scutorum.
B. stands for ovum, not fully matured.
C. (in fig. 1) stands for young ovarian eggs.
C. (in fig. 10) ,, outer sac of connective tissue.
c. stands for inner layer of longitudinal muscular fibres.
D. ,, genital duct.
d. (in fig. 1) stands for epithelium of ovarian wall.
d. (in fig. 3) ,, cement ducts.
gl. stands for pancreatic gland.
GS. or *G.* supraœsophageal ganglia.
GA. ,, genital aperture.
L. ,, labrum.
l. ,, cœca of the so-called liver.
M. ,, mouth.
O. stands for ovarian cœca.
oc. ,, eye.
Od. or *ov.* oviduct.
Oe. ,, œsophagus.
o.n. ,, four optic nerves.
P. ,, pancreatic gland.
p.n. ,, peduncular nerve.
S. (in figs. 4 and 6) stands for stomach.
S. (in fig. 10) stands for funnel at the end of the oviduct.
S'. stands for curious sac.
t. ,, testicular cœca.
W. ,, body-wall.
X. (in fig. 2) stands for yolk-elements of egg.
X. (in figs. 10 and 11) stands for unknown mass.
I.–III. stands for small optical ganglia.

Fig. 1. Part of one of the cœca of the ovarium of *Scalpellum vulgare*, Leach; magnified 685 diameters.

Fig. 2. Nucleus with nucleolus of a nearly ripe ovarian egg of *Scalpellum vulgare*, Leach; magnified 685 diameters.

Fig. 3. Part of a section of the peduncle of *Scalpellum regium* (Wyv. Thoms.), Hoek, in its lower half; magnified 33 diameters. Body-cavity, acting as the main cement duct.

Figs. 4, 5. Pancreatic gland of *Scalpellum parallelogramma*, Hoek.

Fig. 4. Part of a transverse section through the cephalic part of the body; magnified 33 diameters.

Fig. 5. Section of the gland where it has its greatest diameter; magnified 106 diameters.

Fig. 6–9. Anatomy of *Lepas anatifera*, Linné.

Fig. 6. Sagittal section of the body; magnified 1·5 diameters.

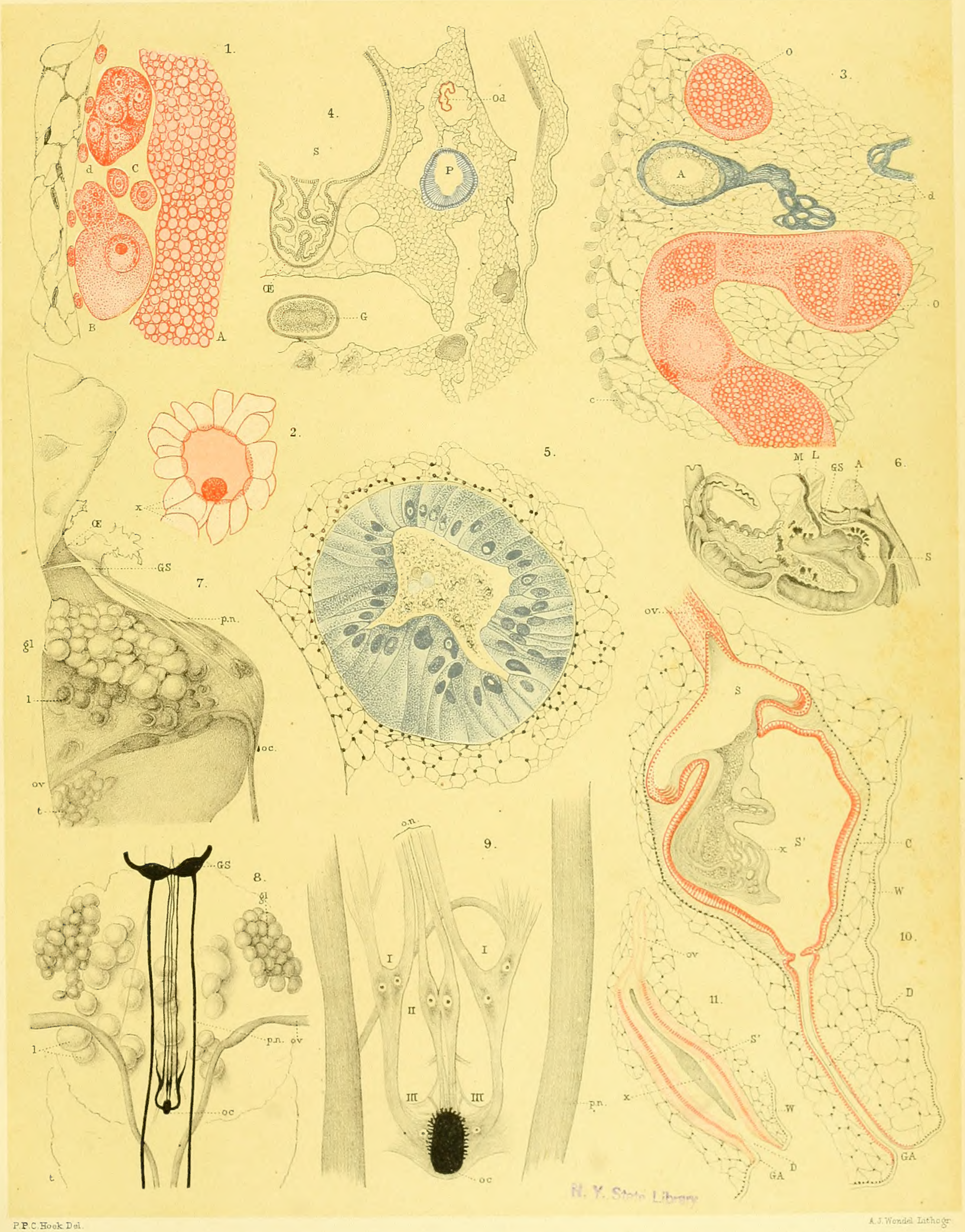
Fig. 7. Lateral view of the upper and front part of the stomach, after the muscles have been removed; magnified 8 diameters.

Fig. 8. Frontal view of a part of the stomach with the supraœsophageal ganglia; magnified 8 diameters.

Fig. 9. The eye and its innervation; magnified 58 diameters.

Fig. 10. The apparatus by means of which the oviduct opens in *Scalpellum vulgare*, Leach; magnified 106 diameters.

Fig. 11. Same apparatus of *Lepas hillii*, Leach; magnified 58 diameters.



P.P.C. Hoek Del.

A.J. Wendel Lithogr.

1-2 SCALPELLUM VULGARE. 3 SC. REGIUM. 4-5 SC. PARALLELOGRAMMA.
6-9 LEPAS ANATIFERA. 10 SC. VULGARE. 11 LEP. HILLII.

Louis W. Hutchins.